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State of Washington

Liberty Lake Source Trace Study

Regarding PCB, PBDE, Metals, and Dioxin/Furan

A Pilot Project for Spokane Basin Source Tracing

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Abstract

This report describes the results of the toxics trace pilot study in the Liberty Lake study area and the next steps for source tracing in the Spokane River Watershed. The results of this pilot study will help us identify and eliminate the sources of contaminants of concern (CoC) in the Spokane River. The following CoC were identified by Ecology's Environmental Assessment Program as high priority: polychlorinated biphenyls (PCB), polybrominated diphenyl ethers (PBDE), dioxin/furan, and select metals (lead, cadmium, zinc).

The goals of this study include:

1. Determining the urban "background" concentration range of CoC from wastewater and storm systems with no apparent industrial point source. For the purpose of this study, background is defined as the urban concentrations of CoC where no known point source exists.
2. Beginning to identify and distinguish between point and non-point sources that contribute CoC to the Spokane River and Spokane Valley-Rathdrum Prairie Aquifer.
3. Evaluating the pilot study's feasibility as an approach for further source tracing in the Spokane basin.

Our sample size and localized area allowed us to tentatively identify urban background concentrations from wastewater and storm systems. It did not, however, allow us to make a statistical determination. The results of this study helped Ecology understand the movement of the CoC within wastewater and stormwater systems and confirmed the studies feasibility.

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Introduction

In 2007, the Washington State Legislature passed the Urban Waters Initiative. Ecology received funding under the Urban Waters Initiative to investigate and clean up three waterways in the state, including the Spokane River. The purpose of the Spokane River Urban Waters Initiative is to find and eliminate sources of the following contaminants identified as high priority contaminants of concern (CoC):

- Polychlorinated biphenyls (PCB)
- Polybrominated diphenyl ethers (PBDE)
- Dioxin/furan
- Metals (lead, cadmium, zinc)

These priority CoC are described in greater detail in a later section of this report.

Ecology's Eastern Regional Office formed a cross-program team to develop a strategy for understanding and eliminating toxics found in the Spokane River. Participating programs include the Water Quality Program, Hazardous Waste and Toxics Reduction Program, and Toxics Cleanup Program.

More than two decades of documentation exists for contamination of the Spokane River with polychlorinated biphenyls (PCB), toxic metals, and other chemicals (e.g., Hopkins et al., 1985; Ecology, 1995; Jack and Roose, 2002). The Spokane River has elevated concentrations of PCB and dioxin/furan as indicated by a series of Ecology sponsored technical reports completed in 2006 (Serdar and Johnson, 2006b; Parsons and Terragraphics Inc 2007). In addition, concentrations of PBDE in fish were highest in the Spokane River according to a statewide study of ten rivers and ten lakes across the state (Johnson et al., 2006).

The Spokane River carries historic mining waste that includes heavy metals such as cadmium, lead, and zinc. Recently, Ecology detected these contaminants in stormwater systems that discharge to the Spokane River (Parsons and Terragraphics Inc 2007). To find out whether metals from the Coeur d'Alene Basin Superfund site were adversely affecting the aquifer's water quality, the United States Geological Survey (USGS) investigated the movement of select metals between the aquifer and river. They concluded wells near the river are not currently at risk for elevated metals from the Coeur d'Alene Basin Superfund site. Similar ion concentrations in the ground and surface water confirm the groundwater-surface water exchange; however, metals concentrations did not indicate an adverse affect to ground-water quality (USGS 2003).

The limited data collected to date indicates the city of Spokane to be a major contributor of some of the CoCs to the Spokane River (Ecology 2007). Unfortunately, the city of Spokane has an old, complicated storm and wastewater system. This makes it difficult to trace source contamination through system sampling.

Before we could investigate sources in the city of Spokane, the following needed to occur:

1. A better understanding of the storm and wastewater collection systems' structure.

2. Ecology needed to complete analysis of PBDE and dioxin/furan in stormwater and sediment collected at river outfalls during 2006. The analysis will help determine the relative contribution of PBDE and dioxin/furan from stormwater to the river.
3. Refining collection methods in a pilot study.

With these steps completed, we will then be able to use our resources in the city effectively.

The Liberty Lake study area is a set of several smaller watersheds (or catchments) within the Spokane River Watershed (Spokane Basin). It does not have any known historic or current industrial point sources of the organic contaminants of concern; however, the waterbody within the study area, Liberty Lake, is on the 303d listing for PCB in fish tissue. This is not a unique situation. At least three other lakes within the Spokane Basin are listed on the 303d list for PCB without any known sources.

The area around all four of the lakes is urbanized. Because of this, the Liberty Lake system was an ideal starting point for understanding background[1] concentrations of these contaminants in urban storm and wastewater systems. It also allowed us to evaluate and improve our sampling and business visit techniques before continuing our source tracing efforts in the larger and more complex city of Spokane system.

Study Design

The primary goals of this study included:

- Determine the background[1] concentration of the CoCs from wastewater and storm systems with no apparent industrial source.
- Begin to identify and distinguish between point and non-point sources that contribute CoCs to the Spokane River and Spokane Valley-Rathdrum Prairie Aquifer.
- Begin to determine the general difference between residential versus business contributions.

Secondary goals include:

- Evaluate the pilot study's feasibility as an approach for further source tracing in the Spokane Basin.
- Determine if any of the additional ten priority pollutant metals (arsenic, silver, antimony, beryllium, chromium, copper, mercury, nickel, selenium, thallium) are present at concentrations of concern in the wastewater and stormwater runoff.
- Determine sources of phosphorus discharge in the sub-basin that includes Liberty Lake.

The study area shown in Figure 1 was chosen for the pilot study because it met the following criteria:

- It is the furthest upstream source from the Idaho/Washington border.

[1] *For the purposes of this study, background means CoC concentrations from residential and industrial systems with no known sources of CoC.*

- The wastewater system is small, discrete, and well known.
- There are stormwater conveyance systems that will provide us data on residential contribution.
- There are new and old community wastewater piping constructed of different material we can isolate and look at more closely.
- There are a variety of facility types that will provide an adequate representation sample of contaminant contributions from industry that are not known to discharge our CoCs.

The need for an additional criterion became apparent at the beginning of the study when we discovered the stormwater collection system needed to be mapped. This assisted with our development of GIS mapping and analysis skills. Understanding hydrology from a spatial perspective is crucial in determining trends and other patterns that assist with source tracing.

Study Area

The Liberty Lake study area is defined below for the purpose of this study only (Figure 1). The study area is bounded by Spokane River to the north, Kramer Hill to the east, Liberty Lake Regional Park to the south, and Carlson Hill to the west. This includes all tributary basins that drain into Liberty Lake and the plateau that infiltrates to the aquifer.

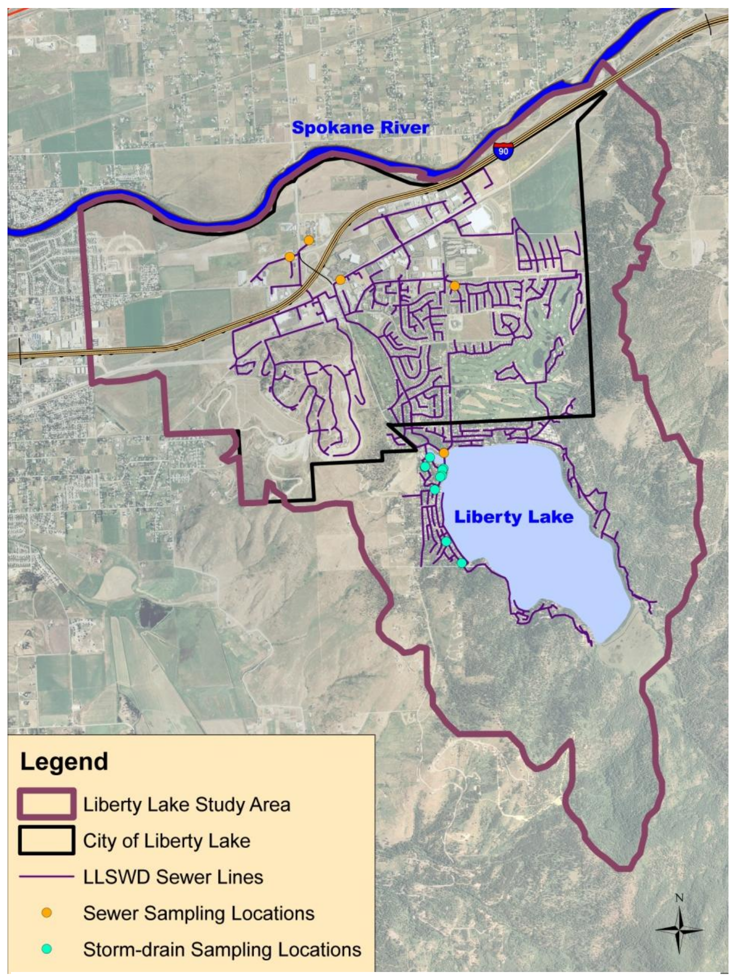

Figure 1. Liberty Lake study area.

The geology includes hills of basalt and granite bedrock on the south end that then flattens out to a plateau composed of sand and gravel to the north. It is part of the Middle Spokane Watershed, which is a sub-watershed within the Spokane Basin.

Spokane County and the city of Liberty Lake are the major land owners within the study area. The city of Liberty Lake is the only city within the study area and is the first city the Spokane River flows past once it crosses the Idaho-Washington state line. The southern portion of the study area, bounded by hills of basalt and granite bedrock, directs surface water to Liberty Lake. Liberty Lake and the stormwater from the plateau infiltrate the aquifer, which then discharges water to the Spokane River west of the city (USGS 2007).

The Liberty Lake Sewer and Water District (LLSWD) provides the majority of the public water for the city of Liberty Lake and operates the city's sole wastewater treatment plant. The plant collects and treats wastewater from industrial, commercial, and residential sources.

The LLSWD encompasses approximately 5,000 acres. The collection system contains structures of various materials from brick and clay to polyvinyl chloride. Its design allowed us to isolate the wastewater from new and old residential communities as well as industrial.

The city's stormwater management system is not connected to the city wastewater treatment system. The community relies on strategically situated drywells for stormwater runoff management. Any business or homeowner construction projects must provide individual drywells to drain stormwater from their property.

The stretch of the Spokane River bordering Liberty Lake is a losing reach, meaning that the river feeds into the aquifer (USGS 2007). This indicates pollution would flow from the river to the aquifer within our study area. This does not relieve the area of pollution control concerns because there is a potential for contamination to infiltrate into the aquifer, which flows in a westerly direction and then recharges the river between the Sullivan Road USGS gauging station and the Centennial Trail Bridge (USGS 2007).

Background – The Bigger Picture

Spokane River/Spokane Valley-Rathdrum Prairie Aquifer

The Spokane River begins at Lake Coeur d'Alene in Idaho and flows 112 miles to the Columbia River and Lake Roosevelt. Major tributaries to the Spokane River include the Little Spokane River and Hangman (Latah) Creek.

The watershed is made up of forest, agriculture, urban and range lands.

Agricultural lands lie primarily in the Lower Spokane, Little Spokane and Hangman Creek Watersheds.

The urban land use occurs mainly in the Middle Spokane watershed, Water Resource Inventory Area 57 (WRIA 57). This is primarily because of the city of Spokane (Figure 2).

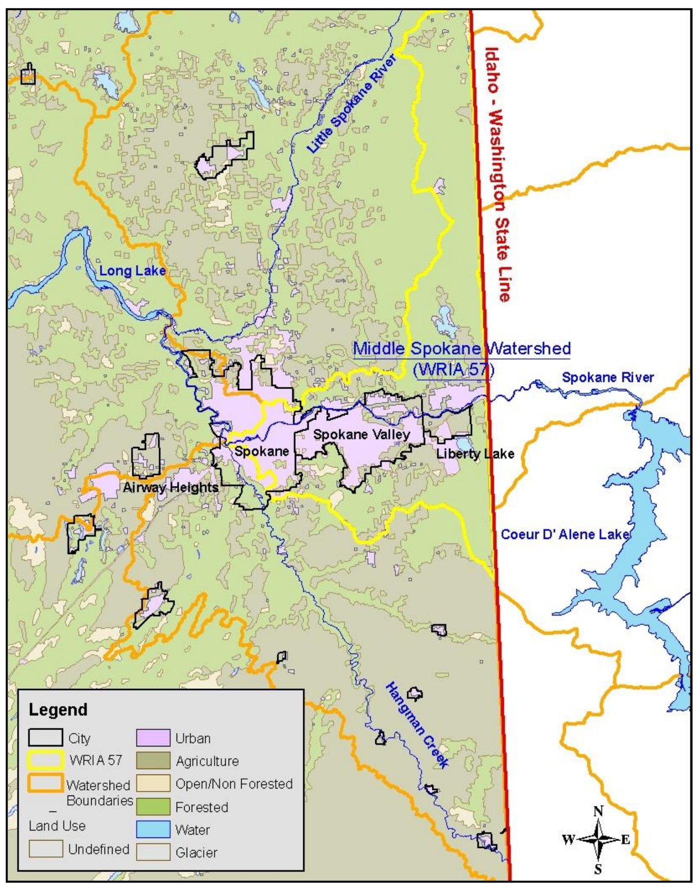

Figure 2. Middle Spokane Watershed land use.

The Spokane Valley-Rathdrum Prairie Aquifer is a sole source aquifer that readily exchanges water with the Spokane River. This increased concern for potential exchange of contaminants between the two water sources (USGS 2003). Over the years, water pollution from a variety of sources contributed to contaminating the river and aquifer. These contaminants of concern come from both point and non-point sources. Point sources are direct discharges such as industrial wastewater from a facility directly piped to a waterbody. Non-point sources are diffuse sources such as air deposition and stormwater runoff.

Contaminants of Concern

Polychlorinated Biphenyls (PCB)

Polychlorinated biphenyls are a group of chlorinated aromatic hydrocarbons containing up to ten chlorine atoms. There are 209 variations called congeners. The number and location of chlorine atoms on the hydrocarbon ring dictates the behavior and toxicity of each congener in the environment (ATSDR[2] 2000). Manufacturers would combine 40-70 congeners to produce aroclors for various applications such as reducing transformer oil flammability. Due to increasing awareness of their toxicity, the United States Environmental Protection Agency (EPA) banned the manufacture of PCB in 1979. Chemical manufacturing currently produces some PCB as by-products (Panero et al. 2005).

PCB enters the Spokane River from industrial discharges, wastewater treatment plants, stormwater, local urban air deposition, and long-range air deposition in the Coeur d' Alene Basin. PCB from mishandling transformers, caulking leachate, and other still unknown sources become mobile during storm events and wash into the river. The Kaiser Trentwood aluminum plant is a well-known historic source in the Spokane Valley. Since 1995, Kaiser has taken major steps to reduce PCB concentrations in its wastewater. Kaiser and Inland Empire Paper each have a National Pollutant Discharge Elimination System (NPDES) permit to manage their PCB-contaminated wastewater. Ecology's Water Quality Program oversees these permits. The General Electric site was contaminated with PCB, impacting the aquifer near the river (Serdar et al. 2006). Ecology's Toxic Cleanup Program oversaw a 1999 cleanup of this site.

The Washington State Department of Health (WDOH) and the Spokane Regional Health District (SRHD) currently have an advisory to avoid or limit consumption of fish in parts of the Spokane River due to elevated PCB levels. The largest concentrations of PCB in fish or sediment have been found between the Idaho border and Upriver Dam.

The ecological implications of PCB contamination in the Spokane River have been assessed by Art Johnson (2001) from Ecology's Environmental Assessment Program. Johnson concluded there may be adverse effects on the salmonid populations, fish-eating mammals, and benthic invertebrates residing in the river reaches downstream of Kaiser. He did not find evidence of risk to fish-eating birds. Johnson points out elevated concentrations of PCB in the fine-grained sediments between Kaiser and Monroe Street Dam as one of the factors influencing his risk calculation for benthic invertebrates. This includes the area behind Upriver Dam. In 2001, Ecology's Toxics Cleanup Program placed a cap on the PCB-contaminated sediments behind Upriver Dam. This may to some degree, have abated the risk to benthic invertebrates.

[2] Agency for Toxic Substances and Disease Registry

Polybrominated Diphenyl Ethers (PBDE)

Polybrominated diphenyl ethers are chemical additives used as a flame retardant in everyday household products. Studies indicate PBDE are building up in people's bodies, animals, and the environment (Serdar and Johnson 2006b; Peele 2004, Johnson and Olson 2001, Johnson et al. 2006). There are no water quality or fish tissue standards for PBDE. Washington State had concerns about increasing levels in the environment, bio-accumulative potential, and effects on neurologic development and reproduction effects in laboratory animals. This prompted the State to develop a plan to reduce PBDE inputs to the environment (Peeler 2004). Ecology recently published data from ten rivers and ten lakes indicating that Spokane River fish tissue contains the highest levels of PBDE of the 20 sites tested (Serdar and Johnson 2006b).

Three formulations of PBDE are in use. Each is a group of congeners at varying concentrations within a similar homologue group. For example, the 'PentaBDE' formulation tends to have congeners with five bromine atoms. The three formulations, PentaBDE, OctaBDE, and DecaBDE, show different levels of toxicity. Manufacturers voluntarily phased out PentaBDE and OctaBDE production. The Ecology plan includes a ban on DecaBDE if a safe and effective alternative flame retardant is found.

PentaBDE was used in furniture and rigid insulation such as mattresses. OctaBDE was used in high-impact plastics such as phones, automobile trim, and computers. DecaBDE is used in all the above applications except mattresses and other materials such as draperies, cable insulation, adhesives, and textile coatings (BSEF 2002, ATSDR 2004).

Dioxin and Furan

As with the PBDE, we do not yet know the full extent of contamination or the sources of dioxin/furan in the Spokane River. Nationwide, polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran (dioxin/furan) have been found in the air, soil, water, aquatic life, food, and people. Chemical production can produce dioxin and furan as a by-product if a halogenated substance is present. For example, dioxin and furan are inadvertently produced during the manufacture of herbicides and paper products. The burning of municipal waste, sludge, medical waste, and wood can produce these contaminants as an airborne particulate (Yake 2000).

Recent screening-level data suggest that dioxin/furan could merit further investigation in the Spokane watershed. Ecology conducted fish sampling in the Spokane River in 2003. A single rainbow trout fillet sample from the Nine Mile reach had a tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) toxic equivalents of 0.36 ng/Kg (Seiders et al., 2006, Seiders et al. 2007). By way of comparison, the EPA National Toxics Rule human health criterion for dioxin/furan in fish tissue is 0.065 ng/Kg. Although the National Toxics Rule criterion is based on human health risks – one in a million excess lifetime cancer risk – it is used to assess water quality violations. It is not a threshold for issuing public-health fish consumption advisories.

Metals

High levels of arsenic, zinc, lead, and cadmium contaminate much of the bottom sediments in the Spokane River (Johnson and Norton, 2001). Ecology developed a total maximum daily load (TMDL) in 1999 that limits zinc, lead, and cadmium discharges to the river (Pelletier, 1998). The arsenic and lead concentrations prompted WDOH and SRHD to issue an advisory urging people to reduce contact with shoreline sediments along parts of the river. In 2003, SRHD issued a sediment advisory for lead and arsenic.

Historic mining practices in Idaho's Coeur d'Alene Basin contribute to the lead and zinc concentrations in the river. The entire basin was designated a Superfund site in 1983 by EPA. Although cleanup is occurring, recent river sampling at the Idaho-Washington border show that dissolved zinc and particulate lead concentrations continue to exceed water quality standards. Fish tissue analysis also showed high levels of lead, zinc, and cadmium from fish collected between the Idaho-Washington border and Lake Spokane (Serdar 2006).

Wastewater and stormwater carry metals to the river as well. For example, zinc migrates into the river during storm events when rain washes particulate into the storm drains from galvanized buildings, stockpiles of galvanized metals, and tire wear from streets and parking lots.

Methods

This study took place according to the methods outline in the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) for the Liberty Lake Source Trace Study Regarding PCB, PBDE, Metals, and Dioxin/Furan (Fernandez and Hamlin, 2008). Deviations from the QAPP are described and explained below.

Field Sampling

The sampling plan included mapping the storm drain system to determine where to sample for stormwater and storm-drain sediment. Completion of the map was necessary before the stormwater and storm-drain sediment locations could be determined. Table 1 shows actual sample locations for all media, parameters measured, and the purpose for taking the sample. Figures B-1 through B-5 in Appendix B show the sample locations.

Table 1. Actual sample locations, purpose, and parameters measured

Location ID	Purpose (Determine contribution)	Sample	Collection Point	Field Parameters	Lab Parameters
Wastewater					
Liberty Lake Wastewater Treatment Plant Influent (WWTP Influent)	Determine presence of PBDE and dioxin/furan during day shift and normal daytime activities. Sample will be taken Wednesday the middle of the workweek to avoid influence of vacation (Wednesday).	12-hr Composite (6a-6p) 12-hr Composite (6:30p-6:30a)	Influent line Influent line	Flow, Dissolved Oxygen, pH	PBDE Dioxin/Furan
AP1-2: Appleway Ave and Liberty Lake Rd	Wastewater predominantly industrial.	Grab	In-line	none	PCB, PBDE, Dioxin/Furan, PPMetals, Total Phosphorus, TSS, TDS, TOC, DOC
MI2-2: Mission Ave and Pepper Ln	Wastewater predominantly vehicle maintenance, powder coating, and auto sales.	Grab	In-line	none	Same as above
OR1-4: Maxwell Ave and Ormond Rd	Predominantly new residential with polyvinyl chloride piping (pvc).	Grab	In-line	none	Same as above
ID1-4: Inlet Drive	Replaced SR1-3 downstream due to access issues. Predominantly old residential with mixed piping material including brick, clay, pvc, concrete, asbestos cement.	Grab	In-line	none	Same as above
Stormwater					
Garry Drive cul-de-sac outfall (Gardens)	New residential (Post 1985)	Grab	Outfall	Temp, Turbidity	PCB, PBDE, Dioxin/Furan, PPMetals, Total Phosphorus, TSS, TDS, TOC, DOC, Conductivity
West LL- Zone2	Old residential piped system (Pre-1985)	Grab	Outfall	Temp, Turbidity	Same as above
West LL- Zone 3B	Old residential piped system (Pre-1985)	Grab	As water enters catch basin	Temp, Turbidity	Same as above
West LL- Zone 3C	Old residential piped system (Pre-1985)	Grab	As water enters catch basin	Temp, Turbidity	PCB, PBDE, Dioxin/Furan, PPMetals, Total Phosphorus, TSS, TDS, TOC, DOC
Storm-drain Sediment					
West LL- Zone 1	Old residential (Pre-1985)	Core Composite	Drywell, Catch basin	Depth to sediment Depth of core	PCB, Dioxin/Furan, PBDE, PPMetals, TOC, Grain Size
West LL- Zone2	Old residential (Pre-1985)	Core Grab	Drywell	Depth to sediment Depth of core	Same as above
West LL- Zone 3	Old residential (Pre-1985)	Core Composite	Drywell, Catch basin	Depth to sediment Depth of core	Same as above

Wastewater System

Figure B-1 in Appendix B shows the wastewater sampling locations.

Samples were taken at the LLSWD Waste Water Treatment Plant to determine the presence of PBDE and dioxin/furan in the system. The LLSWD has data that indicates PCB and metals are present in the wastewater collection system, so a sample was not collected for these contaminants at this sampling point.

Two 12-hour composite samples were collected from the influent line by an ISCO automatic sampling device on Dec. 10 through Dec. 11, 2008 (6 a.m. – 6 p.m., 6:30 p.m. - 6:30 a.m. respectively). The ISCO sampler pulled a sample every 30 minutes. Bottles were custody-sealed and placed on ice for transport. Samples were refrigerated at a temperature below 6 degrees Centigrade. The 6:30 p.m. - 6:30 a.m. sample volume was not sufficient to run total dissolved solids (TDS). Possible reasons for the small volume are low flow conditions or temporary clogging. Lab analysis revealed PBDE and dioxin/furan in the water samples so it was not necessary to collect biosolid samples at a later date. A split sample was taken for the 6 a.m. – 6 p.m. sample.

Samples were collected from four locations within the collection system for reasons described in Table 1. The exact sampling locations were determined using GIS mapping, LLSWD's knowledge and data, and resident's knowledge. Factors taken into account included:

- Observed predominant land use
- Manhole accessibility
- Flow rate (enough to collect a sample using pole sampler)

Samples were collected at the downstream Inlet Drive manhole (ID1-4) instead of the Shoreline Avenue manhole SR1-3 because the wastewater was not accessible through the manhole. No sample was collected from Wicomico Beach (W1-1) because the brick/clay line lacked adequate flow. A new residential sample was not collected at Corrigan Road (ER1-37) because a new residential sample was collected from Maxwell Avenue (OR1-4). An additional sample was deemed unnecessary since statistical analysis was not planned. Total phosphorus was added to the parameter list as requested by the Water Quality Program after the QAPP/SAP was finalized.

Grab samples were collected using a pole grab sampler with a 1-liter glass container obtained from Ecology's Manchester Laboratory (MEL). A new container was used per site. The sampler was dipped into the flow facing upstream and contents were poured into a 2.5-gallon stainless steel container. This was repeated until a sufficient sample volume was reached.

The sample was homogenized for one minute using a stainless steel spoon. Dissolved organic carbon (DOC), total organic carbon (TOC), and total phosphorus sample containers were filled using a 60 mL polypropylene syringe. The DOC sample was filtered using a 0.45 µm filter. A small volume of sample was pushed through each filter before adding to the sample bottle. This reduced the possibility of contamination from the filter or syringe entering the sample bottle.

Filters were exchanged when flow ceased until the container was filled. Except for metals, all other samples were poured into the appropriate lab containers using a stainless steel funnel to direct the flow. The metals sample container was filled directly from the glass collection container to avoid cross-contamination from the stainless steel equipment.

Clean-certified sample containers were obtained from MEL using the containers specified in MEL's Lab Manual - 9th Edition (MEL 2008). Samples were custody-sealed and placed on ice for transport. Samples were maintained at a temperature below 6 degrees Centigrade.

A replicate sample was collected at the MI2-2 manhole by collecting a separate sample directly after the first sample. We collected the replicate by collecting one sample directly after the other. This was consistent with collection methods described in Parsons and Terragraphic's city of Spokane's stormwater outfall study in 2007 (Parsons and Terragraphics Inc 2007).

Stormwater System

Stormwater was collected from two piped stormwater systems that discharge to ground (Figures B-2 through B-5). Three samples were collected from the system draining the old residential neighborhood on the northwest side of Liberty Lake (West LL) (Figures B-3 through B-5). This system was partially piped. One sample was collected from the system draining the newer Gardens and Gardens Ridge residential neighborhoods (Gardens) (Figure B-2). Stormwater samples were collected as discrete grab samples and analyzed separately (see Table 1). The Gardens system sample site was an outfall located at the Garry Drive cul-de-sac where one discrete grab sample was collected for analysis. In both cases, there is no map of the pipes in the system.

All water samples were collected following the methods described for wastewater sampling except for a few modifications. For samples located in West LL-Zone 3B and West LL-Zone 2, the flow was surficial so the collection point was as the water entered the catch basin. An aluminum foil weir (dull side in) concentrated the flow for collection in a 1-liter glass, wide-mouth transfer container. The Gardens outfall discharged several feet above the ground; therefore, the sample was collected directly into the 2.5-gallon stainless steel container.

Sediment was collected on 10/30 and 10/31/08 from the West LL drainage area. Three samples were collected for analysis, two composite sediment samples and one discrete core grab sample, within the West LL drainage area (Table 1). Seven subsamples were composited in West LL-Zone 1 (Z1-A, etc.) and two subsamples in West LL- Zone 3 (Z3-B, etc.). The subsamples were taken from all identified manholes that had visible sediment (Figure B-4 and B-5). Only one location in Zone 2 contained sediment so compositing was not necessary. There was no observed sediment from the Gardens area.

Core grab samples were collected from drywells using a stainless steel auger. An attempt was made to collect at least two cores per site to increase the representativeness of the sample. Storm-drain sediment is heterogeneous in nature. Sediments were placed in a 2.5-gallon stainless steel container and homogenized using a stainless steel spoon. Each subsample was placed in a half-gallon certified clean glass container obtained from MEL. Samples were custody-sealed and placed on ice for transport. Samples were refrigerated at a temperature below 6 degrees Centigrade.

Several samples froze and required thawing before compositing on 11/6/08. The volume of sample placed in the final composites from each subsample was proportional to the estimated percent area it drained within the system. The following formula was used to calculate subsample mass, $subsample\ mass = composite\ sample\ mass * percent\ area\ drained$.

Business Visits

Ecology and SRHD compiled a list of businesses by combining several database searches (i.e., Department of Revenue, Department of Licensing, and Selectory). The list was narrowed down using two methods:

- Business types likely to contain CoC
- Drive-by visual inspection

We cross-referenced using the phone book and drove by some of the locations to confirm the list accuracy. The list was modified when necessary. SRHD mailed a letter to each business that explained they would receive a visit within 30 days. The letter offered them the opportunity to call and set up an appointment that would eliminate the inconvenience of the unannounced visit. A spreadsheet was also provided, requesting a list of possible hazardous materials at their site.

SRHD filled out a checklist that focused on indoor and outdoor pollution-generating activities during the on-site visit. Once completed, the business received a letter explaining the findings and options for improvement. If problems were identified, a 30-day timeline was provided before a follow-up visit to allow them sufficient time to address the areas of concern. This continued until the business resolved the issues. Businesses that did not make requested corrections and had a potential for risk to human health or the environment were referred to Ecology for follow-up action.

Laboratory Analysis

MEL contracted with Pacific Rim Laboratories to analyze samples for PCB congeners, dioxin/furan, and grain size. MEL analyzed samples for all remaining analyses as outlined in Table 2.

Table 2. Analytical methods, reporting limits, and holding times

Analyte	Matrix	Analytical Method	Preservative	Lab	Reporting Limit or MQL	Holding Times
PBDE congener	water	EPA 8270	Cool to 4˚C	MEL	0.002-0.005 µg/L (209, 0.01-0.05 µg/L)	1 year
	soil/sediment				1-5 µg/Kg (209, 2-5 µg/Kg)	
PCB congener	water	EPA 1668A	Cool to 4˚C	Contract	0.01-0.5 ng/L	1 year
TSS	water	EPA 160.2; SM 2540D	Cool to 4˚C	MEL	1 mg/L	7 days
Dioxins/Furan	water	EPA 1613B	Cool to 4˚C	Contract	As defined in EPA 1613A for each congener	1 year
	soil/sediment					
Total Metals: Priority Pollutant list (13 metals)	water	EPA methods 200.8 & 245.1; EPA 6020 & 245.5	(water)- Preserved Nitric Acid Cool to 4˚C	MEL	As listed in Table 5 on p.130 of MEL's User Manual, 9th Edition	6 months Hg: 28 days
	soil/sediment					
TDS	water	EPA 160.1	Cool to 4˚C	MEL	20 mg/L	7 days
Phosphorus	water	SM 4500P-F	HCL to pH≤ 2 Cool to 4˚C	MEL	1 µg/L	28 days
Grain size	soil/sediment	PSEP* 1986B	Cool to 4˚C	Contract	NA	NA
TOC/DOC	water	EPA 415.1 SM 5310B	HCL to pH≤ 2 Cool to 4˚C	MEL	1 mg/L	28 days
TOC	soil	PSEP-TOC; 1986B	Cool to 4˚C	MEL	0.1%	28 days
Conductivity	water	EPA 120.1	Cool to 4˚C	MEL	1 mhos/cm @ 25ºC	28 days

NA = not applicable *MQL = measurement quality limit*

Data Quality

The quality control (QC) procedures routinely used by MEL and their contractors were followed for this project. Case narratives are available from the author (see inside front cover for contact information). Lab measurement quality objectives (MQOs) for this project stated in the QAPP (2008) were met with a few exceptions. Those exceptions are described below in the Laboratory Quality Control Section.

MQOs for field quality control were not specified in the QAPP. Part of this project included determining how much contamination would be present with low-level analysis and what results would be acceptable in relation to field quality control. This was decided after the QAPP/SAP had been written. We listed the type and quantity of field quality control samples we would collect during this pilot. We collected all required samples except:

- A field rinsate blank was not collected for metals analysis to determine whether there was cross-contamination from using stainless steel for collecting sediment for metals analysis.
- The dioxin/furan rinsate blank was lost.

The field rinsate blank for metals will need to be collected and analyzed during future sampling to remove potential bias.

Wastewater and storm water are heterogeneous by nature and known to produce interference during lab analysis, requiring some data to be qualified. This heterogeneity can also cause increased variability in replicate samples. The data generated during this pilot study can be used for source tracing.

The rinsate blank and field blank contamination was of concern and is discussed below. Some decontamination procedures include a hexane rinse after the acetone rinse. Because of the risk hexane poses to human health, an additional acetone rinse will be included during future decontamination. Furthermore, we will use various lab grade de-ionized and carbon-filtered water and test to make sure the water was not causing contamination issues. In turn, clean-certified bottles could contribute to contamination. We will investigate this possibility as well.

Laboratory Quality Control

MEL provided case narratives with summaries on the following procedures completed:

- analytical method
- holding times
- tuning
- calibrations
- method blanks
- matrix spikes
- laboratory control samples
- surrogate recoveries
- internal standards
- duplicates
- any discrepancies and corrections made after review of the contract lab's case narratives.

A case narrative includes any problems encountered during the analysis. It should include definitions of all data qualifiers or flags. Any deviations of QC results outside of laboratory acceptance limits should be described with the corrections taken by the lab. In addition, any factor that could affect sample results should be discussed.

The following flags were used by Manchester Lab to qualify the data where appropriate:

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

UJ = The analyte was not detected above the reported sample quantitation limit; however, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

N = The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."

All data flagged with a U or UJ were not included in summations or calculations with the exception of dioxin/furan TEQ calculations discussed later. MEL qualified data with a J for these reasons:

- Low surrogate recovery.
- Holding time elapsed before analysis.
- Matrix spike recoveries less than acceptance limit.
- Internal standard recoveries greater than acceptance limit.
- Continuing calibration check failed high.

Two TDS samples were J-qualified because they were analyzed past their holding time.

Tables C-1, C-2, and C-3 in Appendix C contain raw metal results. One of the continuing calibration checks for beryllium failed high, so all beryllium results are qualified with a J. MEL J-qualified the antimony, copper, and lead results for site West LL-Zone 3 due to a matrix spike recovery less than the acceptable limit.

Some wastewater results are qualified with a J to indicate they are considered an estimate. The zinc replicate sample for site MI2-2 is qualified with a J because the matrix spike recovery was lower than the acceptance limit of 75%. Beryllium results for sites MI2-2 and OR1-4 are qualified with a J because the internal standard recoveries were greater than the acceptance limit of 125%.

PCB were measured down to parts per quadrillion increasing the potential for contamination. Data is qualified with a J to reflect this issue. One of the biggest concerns for qualified PCB congener data is the UJ qualification for PCB-11. This has been linked to inks and would be very useful for source tracing; however, the concentrations, although relatively high in the samples, were qualified with a UJ due to the result being less than ten times the lab blank concentration. We modified the flags from the lab to be consistent with the decision on when to accept data affected by blank contamination (J for results between five and ten times the blank result and B for results less than five times the blank result). All useable data is in bold in the tables that follow.

Field Quality Control

Transfer blanks, rinsate blanks, and replicates were taken to assess field sampling quality control. Data is qualified with a J if the blank showed contamination of results between five and ten times the associated blank concentration. Data less than five times the blank concentration are flagged with a B and will not be used in this study or future source tracing efforts. For the organic CoC, summed data are also qualified with a J if the sum of the J-qualified congeners is more than 10% of the calculated total.

We were able to collect and analyze all blanks required by the QAPP/SAP except dioxin/furan and metals in the sediment rinsate blank. The dioxin/furan sample was collected but was lost somewhere during the transport and analysis.

Table 3 lists the blank results and indicates which samples were qualified due to contamination. The stormwater transfer blank results showed a PBDE-99 concentration of 0.006 µg/L. The rinsate blank did not detect any contamination and was collected at the same time. This may indicate that the bottles for the transfer blank were contaminated.

Table 3. Field quality control blank samples and the associated data flagged

Sample type	Date Collected	Analyte	Results	Congener Results Flagged
Stormwater Transfer Blank (TB)	11/7/09	Total Phosphorus	ND (<0.005 mg/L)	---
Stormwater TB	11/7/09	PP Metals	ND	---
Stormwater TB	11/7/09	Dioxin/Furan as 2,3,7,8-TCDD	ND	---
Stormwater TB	11/7/09	Total PCB congener	197.3 pg/L	West LL-Zone 3C West LL-Zone 3B West LL-Zone 2 Gardens
Stormwater TB	11/7/09	Total PBDE	0.006 µg/L	West LL-Zone 3C Gardens
Wastewater TB	2/19/09	Dioxin/Furan as 2,3,7,8-TCDD	ND	---
Wastewater TB	2/19/09	Total PBDE	ND	---
Wastewater TB	2/19/09	Total PCB congener	95.7 pg/L	AP1-2 MI2-2 and Rep. SR1-2 OR1-4
Wastewater TB	2/19/09	PP Metals	ND	---
Sediment Decontamination Rinsate Blank (RB)	11/6/08	Dioxin/Furan as 2,3,7,8-TCDD	Sample lost	---
Sediment RB	11/6/08	Total PBDE	ND	---
Sediment RB	11/6/08	Total PCB congener	549.8 pg/L	---
Sediment RB	11/6/08	PP Metals	Not analyzed	---
Sediment RB	11/6/08	Total Phosphorus	ND (<0.005 mg/L)	---

Replicate samples were also collected to verify homogeneity (or total variability) of samples. Sample precision is reported as relative percent difference (RPD) for pairs of data. RPD is the absolute difference between the sample pair divided by their mean times 100. Table 4 shows the RPD for field samples. Select individual congeners and totals were used to assess total variability. Replicates were not collected for the general parameters TOC, DOC, TDS, TSS, or grain size. RPDs ranged from 2.3% to 90.9%. Eleven of the 25 RPDs were not applicable because the sample and/or the replicate were below the detection limit. Of the 14 RPDs above detection limits, seven RPDs fell below 50% and seven were above 50%. The MI2-2 wastewater replicate contained all 7 RPDs above 50%.

This increased variability was expected for the MI2-2 wastewater replicate. The variability for the MI2-2 sample is most likely due to a visible change in flow in the main pipe while collecting the second grab sample immediately after the first indicating the source contributions from that pipe were different. Wastewater water is heterogeneous in nature also contributing to the variability. Although it can be argued that this may not qualify as a replicate because of this observation, this was collected as a field replicate so will be reported as such.

Table 4. Field quality control replicate samples and percent RPD

Sample Type	Analyte	Media	Sample	Replicate	Average	%RPD
WWTP Influent	2,3,7,8 – TCDD (pg/L)	water	**1.9**	**2.17**	**2.04**	**13.3**
WWTP Influent	PBDE total (ug/L)	water	**0.156**	**0.148**	**0.152**	**5.3**
WWTP Influent	PBDE-47 (ug/L)	water	**0.044 J**	**0.041 J**	**0.042 J**	**7.0**
MI2-2 wastewater	2,3,7,8-TCDD (pg/L)	water	0.5 U	0.5 U	NA	NA
MI2-2 wastewater	OCDD (pg/L)	water	**15.4**	**8.4**	**11.9**	**58.8**
MI2-2 wastewater	PBDE total (ug/L)	water	**0.262 J**	**0.092 J**	**0.177**	**96**
MI2-2 wastewater	PBDE – 47 (ug/L)	water	**0.072**	**0.027**	**0.050**	**90.9**
MI2-2 wastewater	PCB total (pg/L)	water	**5275 J**	**3624 J**	**4450 J**	**37.1**
MI2-2 wastewater	PCB-77 (pg/L)	water	10 UJ	10 UJ	NA	NA
MI2-2 wastewater	PCB-126 (pg/L)	water	15.8	10 UJ	NA	NA
MI2-2 wastewater	PCB-169 (pg/L)	water	10 UJ	10 UJ	NA	NA
MI2-2 wastewater	PCB-11 (pg/L)	water	**462**	**200 J**	**331**	**79.2**
MI2-2 wastewater	Antimony (ug/L)	water	**0.53**	0.2 U	NA	NA
MI2-2 wastewater	Arsenic (ug/L)	water	**3.07**	**3.00**	**3.04**	**2.3**
MI2-2 wastewater	Beryllium (ug/L)	water	**0.10 J**	0.10 U	NA	NA
MI2-2 wastewater	Cadmium (ug/L)	water	**0.12**	0.10 U	NA	NA
MI2-2 wastewater	Chromium (ug/L)	water	**1.48**	**0.82**	**1.15**	**57**
MI2-2 wastewater	Copper (ug/L)	water	**45.3**	**32.7**	**39.0**	**32.3**
MI2-2 wastewater	Lead (ug/L)	water	**0.95**	**0.45**	**0.70**	**71**
MI2-2 wastewater	Mercury (ug/L)	water	0.05 U	0.05 U	NA	NA
MI2-2 wastewater	Nickel (ug/L)	water	**1.90**	**1.00**	**1.45**	**62.1**
MI2-2 wastewater	Selenium (ug/L)	water	**0.58**	0.50 U	NA	NA
MI2-2 wastewater	Silver (ug/L)	water	0.10 U	0.10 U	NA	NA
MI2-2 wastewater	Thallium (ug/L)	water	0.10 U	0.10 U	NA	NA
MI2-2 wastewater	Zinc (ug/L)	water	**136**	**77.7 J**	**107**	**54.5**
West LL – Zone 1	2,3,7,8-TCDD (ng/Kg)	sediment	**1.1**	**0.82**	**0.96**	**29.2**

J = The analyte was positively identified. The resulting concentration is an estimate.
NA = not applicable
U = Not detected at the sample quantitation limit shown
***Bold =** A detected compound*

Results and Discussion

Table 5 provides a summary of CoC concentration ranges found in stormwater, wastewater, and sediment.

Table 5. Range of concentrations found in stormwater, wastewater, and sediment

Parameter	Stormwater (µg/L)		Wastewater (µg/L)		Storm-drain Sediment (mg/Kg)	
	Min	Max	Min	Max	Min	Max
Total PBDE (µg/Kg sediment)	0.0008	0.073	0.139	1.079	5.9	10.9
Total PCB (ng/L for water; ng/Kg sediment)	0.4582	8.4154	1.9634	12.3662	4.78	13.6
Dioxin/Furan (TEQ in pg/L water; TEQ in ng/Kg sediment)	1.61	8.14	0.22	10.49	2.1	9.09
Total Phosphorus	557	956	4920	8230	NA	NA
Antimony	<0.2	0.72	<0.2	0.62	0.16	0.3
Arsenic	0.41	4.57	2.64	3.17	9.87	11.6
Beryllium	<0.10	0.19	<0.10	0.10	0.44	0.49
Cadmium	<0.10	0.18	<0.10	0.13	0.18	0.508
Chromium	0.55	11.8	0.82	9.41	12	24.6
Copper	1.09	13.9	32.7	101	13.4	43.8
Lead	0.31	16.6	0.45	1.58	22.3	43.1
Mercury	<0.05	<0.05	<0.05	0.101	0.014	0.055
Nickel	0.33	7.9	1.00	16.9	10.7	18.5
Selenium	<0.50	<0.50	<0.50	0.94	0.38	0.5
Silver	<0.10	<0.10	<0.10	1.61	0.064	0.49
Thallium	<0.10	<0.10	<0.10	<0.10	0.12	0.16
Zinc	61.1	130	77.7	180	152	220

Conventional Parameters

Storm-drain Sediment TOC, Percent Solids, and Grain Size

Sediment was analyzed for TOC, percent solids, and grain size (Table 6). Percent fines were calculated by summing the silt and clay fractions. The organic contaminants and some of the metals have been associated with the fine fraction of sediment.

The percent of total organic carbon was similar in all three old residential samples. The percent fines varied greatly ranging from 5.77% to 35.1%. This differs from the catch basin sediment sampling conducted in 2007 (Parsons and Terragraphics Inc 2007) where fines were less than 1% of the total sediment collected. This is likely due to where the samples were collected. In-line sediment collection does not allow for an extended residence time where sediment particles can settle out of the water. Catch basins increase retention time of water allowing smaller and lighter fine particles to settle out. Drywells act as filters and adsorb compounds as they pass through.

Table 6. Grain size, total solids and TOC results for storm-drain sediment composites (%)

Site ID	TOC	Total Solids	Gravel	Sand	Silt	Clay	Fines (clay+silt)
West LL – Zone 1	4.11	73.6	33.4	49.5	16.5	4.2	20.7
West LL – Zone 2	3.54	65.4	54.6	48.6	4.26	1.51	5.77
West LL – Zone 3	3.76	64.1	22.4	48.6	27.8	7.25	35.1

Stormwater

Five general parameters were collected because they may assist with source contribution if found to associate with the CoC (Table 7). Any associations found are discussed in the CoC sections below. All general parameters were higher in the old neighborhood. The largest differences were seen in conductivity, turbidity, TSS, and TDS. This may be due to the higher percentage of unpaved surfaces in the old neighborhood. West LL – Zone 2 had the highest TOC and DOC. The catch basins and outfall drywell contained significant amounts of plant matter and the drywell had a strong hydrogen sulfide odor.

Table 7. Stormwater results for conductivity, DOC, TOC, TDS, TSS, and turbidity in mg/L, except where noted

Analyte	West LL-Zone 3C	West LL-Zone 2	West LL-Zone 3B	WestLL Mean (Old Residential)	Gardens (New Residential)	Stormwater Range
Conductivity (umhos/cm)	---	155	117	136	25.8	25.8 - 155
TOC	17.1	121	31.5	56.5	37.3	17.1 - 121
DOC	13.5	115	29.7	52.7	30.9	13.5 - 115
TSS	12	140	370	174	4	4 - 370
TDS	60	211	94	122	13	13 - 211
Turbidity (NTU)	28.4	29.2	279	112	5.17	5.17 - 279

Stormwater samples were not collected from industrial locations. Liberty Lake offered only one industrial stormwater sampling opportunity of interest. A sample was not collected from this location due to possibly interfering with on-going compliance issues with the facility. Future sampling in Spokane will include individual industrial facilities to help fill this data gap. A total of 23 parameters were analyzed. Samples were collected from new and old residential neighborhoods to determine relative contributions.

Wastewater

In-line

Conventional parameters were analyzed for the four wastewater pipe samples collected throughout the system as shown in Figure B-1 (Table 8). The wastewater results for TSS, TOC, and DOC differ from the stormwater numbers in that the ranges are narrower and fall within the stormwater ranges. TDS has a narrower range as well, but all four values are above the range for the stormwater results.

Table 8. TOC, DOC, TSS, and TDS concentrations for wastewater pipe samples in mg/L

Site ID	TSS	TDS	TOC	DOC
AP1-2	161	443	105	86.2
OR1-4	114	342 J	101	104
SR1-2	172	329 J	65.6	67.6
MI2-2	95	361	115	92.8

Waste Water Treatment Plant

The volume of night (6:30 p.m. – 6:30 a.m.) influent was insufficient to collect a TDS sample for analysis, possibly due to clogging or low flow. TOC, DOC, and TSS were lower for the nighttime sample. The unknown factor that caused the low sample volume for the night influent sample prevents us from making any generalized conclusions about the difference in concentrations from the day influent sample (Table 9). It should be noted that the DOC and TOC concentrations for the day (6:00 a.m. – 6:00 p.m.) influent sample are several times higher than the highest concentrations found in both stormwater and wastewater.

The LLSWD provided the following data [temperature, pH, and average dissolved oxygen (DO) as well as total 12-hour flow in million gallons (MG)] in Table 10 for the sampled time periods. Although flow was lower during the night sampling event, all other parameters were similar.

Table 9. TOC, DOC, TSS, and TDS concentrations for Liberty Lake Sewer and Water District wastewater treatment plant influent 12-hour composite samples in mg/L

Site ID	DOC	TDS	TOC	TSS
Influent Day	485	364*	532	179*
Influent Night	71.8	Not analyzed	88.5	138

**Average of result and lab duplicate*

Table 10. LLSWD wastewater treatment plant pH, DO, temperature, and flow averages for December 10 and 11, 2008

Site ID	pH	DO (mg/L)	Temp (C)	12-Hr Flow (MG)
Influent Day	8.27	3.2	15.7	0.351
Influent Night	8.49	3.8	16.3	0.238

PBDE

Table 11 shows the analytical results for PBDE in all three matrices sampled. The number of samples and the heterogeneous nature of all matrices sampled do not allow us to make statistically significant conclusions about PBDE. This is true for all matrices and all CoC. The most notable observations are:

- PBDE were found in most samples.
- Concentrations were consistently higher in the wastewater system compared to the stormwater.
- More PBDE congeners were found in the wastewater than stormwater. The increased number of congeners may be due to the additional octaBDE formulation products or from breakdown of PBDE-209 by bacteria in wastewater. In addition, stormwater exposure to ultraviolet light (UV) may also be a factor. UV breaks down PBDE-209, PBDE-153, PBDE-154, and PBDE-183 to various degrees.
- PBDE may be accumulating in the storm-drain sediment.
- Interferences will need to be corrected to reduce the amount of qualified data; however, the nature of the matrix may not allow for less variability.
- PBDE were higher in concentration than PCB.

Table 11. PBDE values by matrix

Site ID	PBDE Total
Storm-drain Sediment in µg/Kg dw	
West LL-Zone 1	**10.9**
West LL-Zone 2	6.8 U
West LL-Zone 3	**5.9**
Stormwater in µg/L	
West LL-Zone 2	**0.0482**
West LL-Zone 3B	**0.0058**
West LL-Zone 3C	**0.073**
Gardens	**0.0008 J**
Wastewater in µg/L	
Influent Day [1,2]	**0.150 J**
Influent Night[1]	**0.139 J**
AP1-2	**0.316 J**
MI2-2	**0.262**
MI2-2 Rep.	**0.092**
MI2-2 Mean	**0.177**
OR1-4	**1.079 J**
SR1-2	**0.355 J**

[1]12-hour composite sample; [2]Average of two replicates
***Bold** = A detected compound*
U = Not detected at the sample quantitation limit shown
J = An estimated concentration
B = Result less than five times the field blank.

Storm-drain Sediment

PBDE storm-drain sediment results can be found in table C-4 in Appendix C. PBDE sediment concentrations ranged from non-detect to 10.9 µg/Kg dry wt. Only three congeners were found, which include 47, 99, and 100. These congeners are associated with the penta formulation used in polyurethane foam for upholstered furniture and rigid insulation. They are known to volatilize and travel long distances via air masses before redepositing on the ground (Wania and Dugani, 2002). Interestingly, we detected BDE-209 in the stormwater entering these systems but did not find it in the sediment. We did however, find BDE-100 in storm-drain sediment, which was not detected in the stormwater. This may be a sign of debromination in the sediments or movement of BDE-209 through the drywell base. Another explanation may be that the detection limits for BDE-100 in water are too high thus some congeners show up in sediment after temporal accumulation.

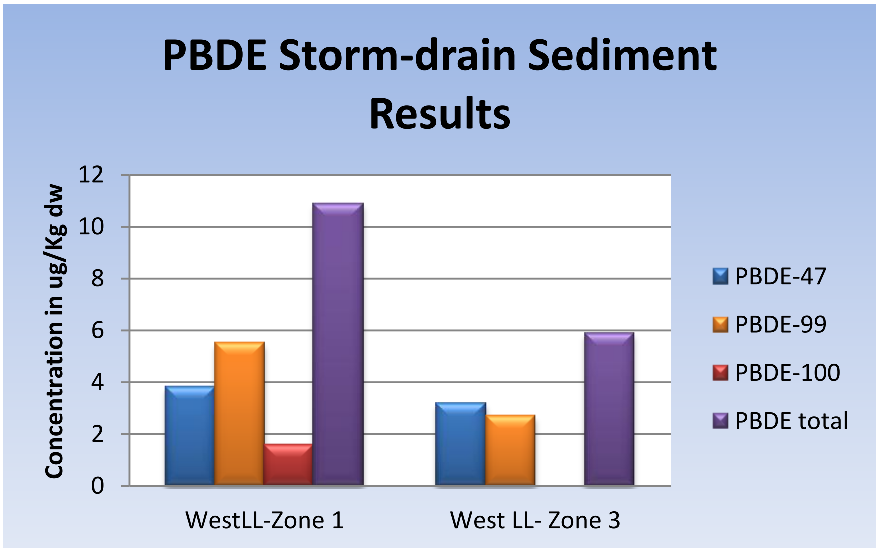

Figure 3. Storm-drain sediment results for PBDE in µg/Kg dw.

Researchers have linked TSS with PBDE concentrations, which is supported by the limited data collected for this project; however, it is also believed PBDE in sediment are associated with the fine fraction, less than 62 microns (Kersten and Smedes, 2002). In our limited sampling, this association is not as clear.

Table 12 shows the storm-drain sediment results along with the percent fines and TOC. When compared to marine sediment samples collected by King County, both Zone 1 and Zone 3 concentrations exceed the marine sediment range maximum of 3.18 µg/Kg DW (KCDNRP, 2009). In both cases, percent fines are higher in our samples. Because PBDE are associated with fine sediment, the higher percent fines could explain our higher concentrations.

Table 12. Total PBDE storm-drain sediment results, percent fines, and percent TOC

	West LL-Zone 1	West LL-Zone 2	West LL- Zone 3
PBDE Total (µg/Kg DW)	10.9	6.8 U	5.9
TOC (%)	4.11	3.54	3.76
Fines (%)	20.7	5.77	35.05

U = not detected at the sample quantitation limit shown.

Stormwater

All stormwater samples contained some PBDE (Table C-5), but the transfer blank also contained PBDE. PBDE-99 results were not used for this reason as described in the Quality Control Section (data is qualified with a B). The PBDE-47 and PBDE-209 were present in two samples (Figure 4).

It is important to note that two of the four results were higher in concentration than all stormwater samples collected from the city of Spokane in 2007 (Parsons and Terragraphics Inc 2007); however, they did not detect PBDE-209, which is the main reason for the high concentrations. Their concentrations for PBDE-47 were higher than any sample from Liberty Lake.

It is also worth noting that the old residential concentrations were all higher than the new residential concentrations. The new residential area is mostly concrete and asphalt, while the old areas were unpaved or without sidewalks. The amount of sediment and debris within the old neighborhoods was much higher than in the new. Further sampling is needed to gain a better understanding of the difference. It may be worth comparing drainage catchments in Spokane that differ in age and in their paved surface areas.

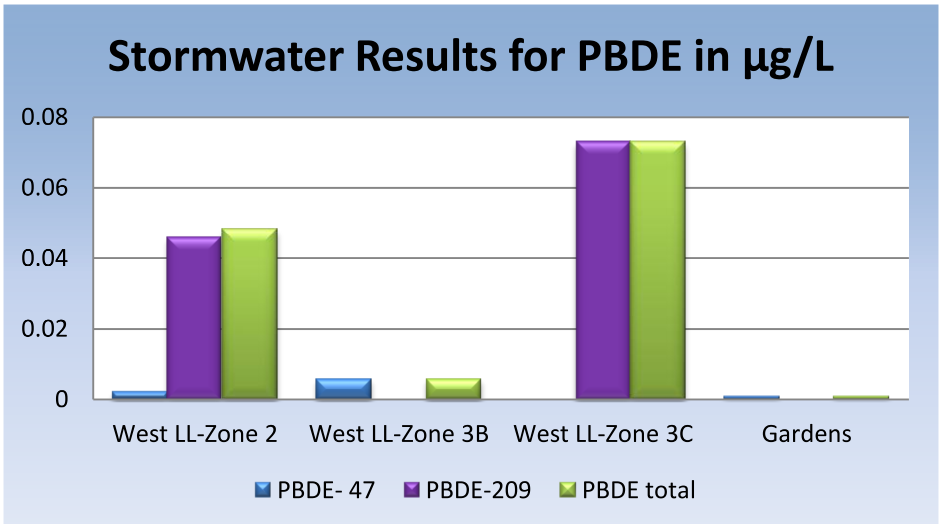

Figure 4. PBDE results in stormwater.

Wastewater

All wastewater samples contained some PBDE at high concentrations relative to the stormwater results (Figure 5, Table C-6). Additional congeners were detected including BDE-153, BDE-154, and BDE-183. These congeners are linked with the pentaBDE and octaBDE formulations. The new residential waste contained more PBDE than any other branch that included industrial and old residential. Possible explanations, although not observed, could be a slug of water may have passed through during sampling that was of a higher concentration than usual (furniture cleaning wash water, for example).

Both composite day and night samples at the treatment plant were lower than all but the second replicate sample from MI2-2. Either we happened to choose branches that contained higher levels of the PBDE, or concentrations change throughout the day and we may have chosen a time of day when discharge is the highest. The exact reason for this anomaly is unclear. Follow up sampling could include additional branch samples at different locations and treatment plant samples at different times of day. This should be taken into account and tested in the city of Spokane.

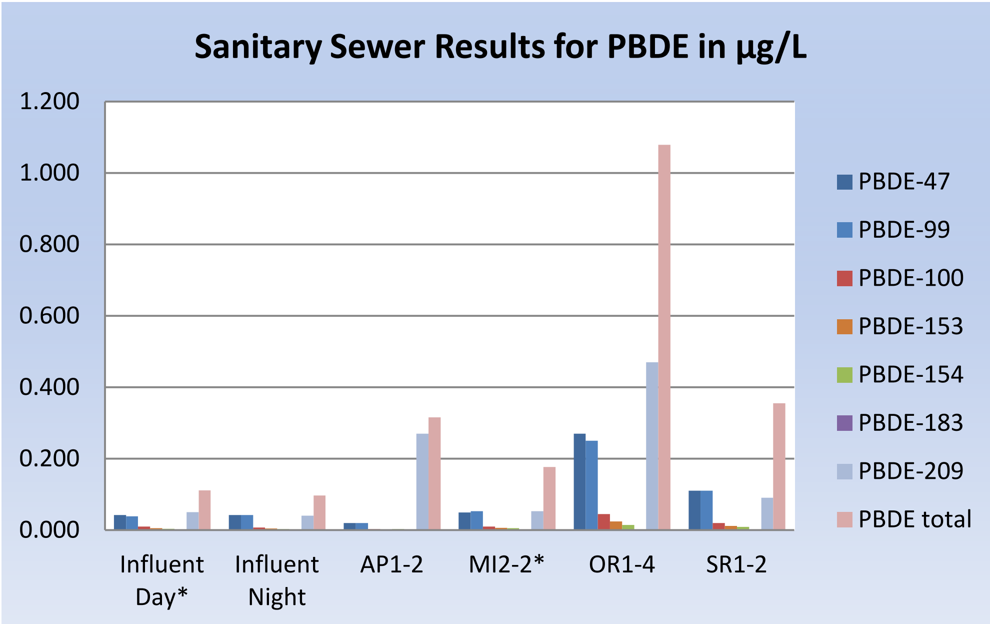

Figure 5. Wastewater results for PBDE **Average of duplicates.*

PCB

The Liberty Lake study area does not have any known current or historical point source PCB contamination, so it seemed like the ideal location to begin to understand the local urban "background" concentrations. Basically, all conditions are similar to the city of Spokane except the lack of extensive industry and the knowledge that there should not be a current or historical point source contributing to the media sampled.

We cross-referenced PCB with the 303(d) listings on Ecology's Water Quality Assessment for Washington internet mapping tool and found that Liberty Lake was listed as a 303(d) impaired water body for PCB. This listing was determined based on two fish tissue composite samples (5-10 fish), one from 2001 and one from 2005. A wider view of Spokane County showed at least three other lakes also received the 303(d) listing without a known or suspected source. Expanding the search to the whole state, it is estimated that 75% of all sites tested for fish tissue PCB concentrations exceed water quality criteria and are listed as 303(d) impaired water bodies. Art Johnson with Ecology is in the process of releasing a publication that attempts to explain this phenomenon (Johnson, 2008).

For Liberty Lake, this may be due to several factors that are not linked to historical contamination. For example, any of the following could contribute to contamination:

- Stormwater runoff from streets with electrical transformers or other PCB-containing material (caulking, etc).
- Residential sewage leakage.
- Aerial deposition.
- Stocked fish contaminated with PCB from maternal or paternal transport.

PCB congener results can be found in Appendix C (Table C-7). PCB were found at low levels in all samples collected. The highest water concentration measured was from the older residential neighborhood wastewater. Data are presented as totals and summed homologues in this section. Homologues are the sum of the congeners with similar numbers of chlorine atoms. For example, MonoPCB equals 1 chlorine atom, DiPCB equals two chlorine atoms, and so forth.

Storm-drain Sediment

We found PCB in all three storm-drain sediment samples (Table 13). Concentrations ranged from 4.78 – 13.6 µg/Kg dry weight (DW). A similar source tracing study is underway by the Lower Duwamish Waterway Group for PCB and other contaminants (WindWard Environmental LLC 2007). They calculated the urban background concentration from various locations for PCB (e.g., Green river sediment and a collection of urban bays). It ranged from 21 – 135 µg/Kg DW, which is above the concentrations we found in Liberty Lake.

These concentrations, in conjunction with the stormwater data, indicate a low-level source of PCB that accumulates in the sediment.

Table 13. Storm-drain sediment results for PCB in µg/Kg DW

Parameter	WestLL - Zone 1*	WestLL - Zone 2	WestLL - Zone 3*
MonoPCB	0.003 U	0.003 U	0.0143
DiPCB	**0.0131**	**0.0144**	**0.0498**
TriPCB	**0.0043**	**0.044 J**	**0.0644**
TetraPCB	**0.0967**	**0.604 J**	**0.575**
PentaPCB	**1.33**	**2.76**	**3.78**
HexaPCB	**1.94**	**2.01**	**4.50**
HeptaPCB	**1.06**	**0.79**	**3.65**
OctaPCB	**0.26**	**0.19**	**0.82**
NonaPCB	**0.0507**	**0.032**	**0.048**
DecaPCB	**0.0266**	**0.0358**	**0.133**
Total PCB	**4.78**	**6.48 J**	**13.6**

***Composite** *U = Not detected at the sample quantitation limit shown* *J = An estimated concentration*

Stormwater

Total PCB concentrations in stormwater ranged from 458.2 to 8415.4 pg/L (Table 14). All stormwater samples exceeded the 170 pg/L NTR criterion for the protection of human health. Therefore, they also exceeded the significantly lower Spokane Tribal PCB standard of 3.37 pg/L, which applies to the Spokane River downstream of Long Lake Dam. None of the samples violated the freshwater acute or chronic Toxics Substances Criteria found in table 240(3) of the Water Quality Standards for Surface Waters of the State of Washington.

The PCB stormwater concentration median was 5.04 ng/L, which is lower than the median concentration of 7.71 ng/L found in the 2007 Spokane PCB stormwater project completed by Parsons and Terragraphics Inc in 2007 (Parsons and Terragraphics Inc. 2007). The PCB stormwater concentration mean was 4.62 ng/L, which is well below Parsons and Terragraphics mean of 22.5 ng/L.

Table 14. Stormwater results for PCB in pg/L

	West LL-Zone 2	West LL-Zone 3B	West LL-Zone 3C	Gardens
MonoPCB	**11.1**	10 UJ	10 UJ	10 U
DiPCB	**438.3**	**638.5**	10 UJ	**481.2**
TriPCB	**692.9**	**611.5**	**128.6**	**930.4 J**
TetraPCB	**735.5**	**931.4**	**87**	**352.8 J**
PentaPCB	**2496.2**	**2612.9**	**157.3 J**	**20.9**
HexaPCB	**2883.7**	**1522**	**50.2**	10 U
HeptaPCB	**773.5**	**986.6**	**35.1**	10 U
OctaPCB	**261.5**	**286.1**	10 UJ	10 U
NonaPCB	**77.8**	**143.1**	10 UJ	10 U
DecaPCB	**44.9**	**84.2**	10 UJ	10 U
Total PCB	**8415.4**	**7816.3**	**458.2 J**	**1785.3 J**

Bold *= Visual aid for detected compounds;* *UJ = Estimated detection limit*

Figure 6 shows a visual comparison of percent homologues for the stormwater and storm-drain sediment. Total PCB results were dominated by the tetra, penta, hexa, and hepta PCB congener groups. The congeners with the lesser number of chlorine atoms do not appear to be as prevalent in the storm-drain sediment as they are in the stormwater. This may indicate they readily pass through the drywell or are dechlorinated and broken down into other compounds.

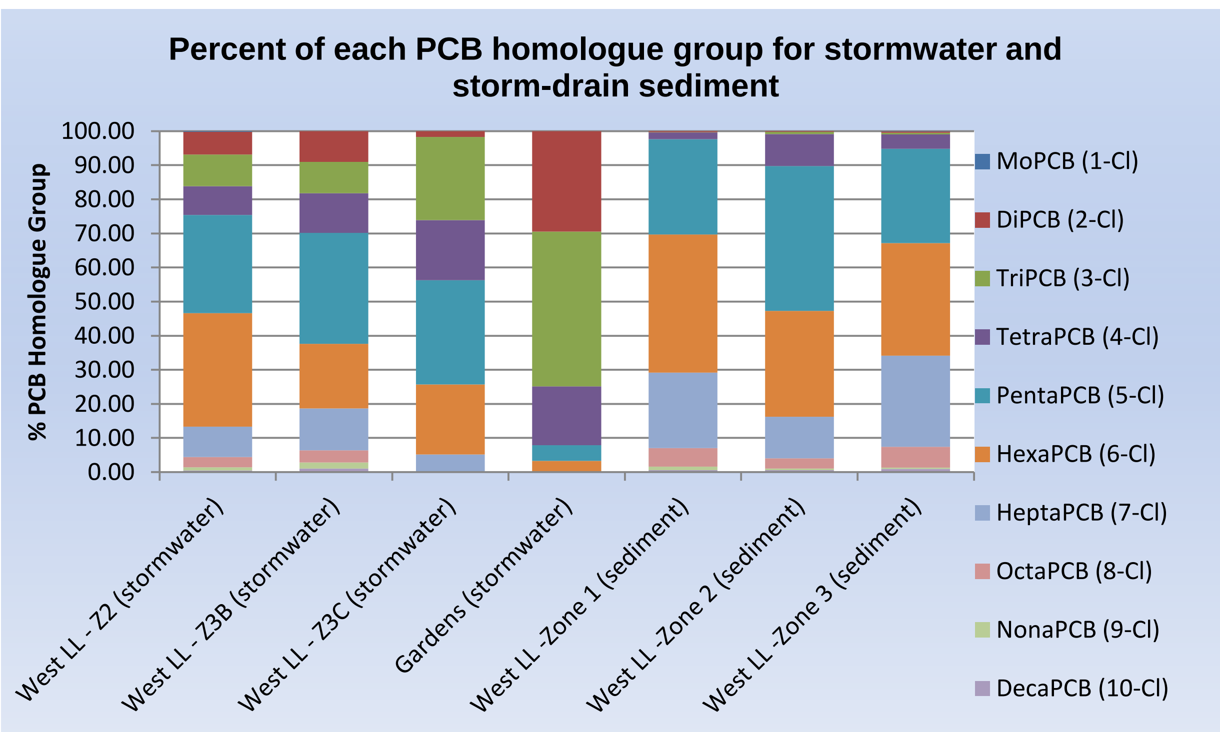

Figure 6. Percent contribution pattern of PCB congener homologue groups per site for stormwater and storm-drain sediment.

Wastewater

Results for wastewater PCB concentration totals ranged from 1963.4 – 12366.2 pg/L (Table 15). The average concentration in the wastewater was slightly higher than stormwater, 6534.2 pg/L versus 4618.7 pg/L respectively. Further sampling may show a different trend since our sample number is small.

A visual comparison of homologue groups of storm and wastewater samples shows a relatively similar pattern for all but the Gardens stormwater sample (Figures 7 and 8). The Gardens sample is from the newer residential area consisting of concrete vaults, sidewalks, and pavement. The remaining three stormwater samples come from older residential with paved and unpaved roads, and intermittent sidewalks. The lighter di, tri, and tetra homologues dominate the Gardens' new residential stormwater, while the old residential wastewater and stormwater include a larger suite with penta, hexa, and hepta in similar percentages as the lighter homologues that dominated the Gardens sample.

Table 15. Wastewater results for PCB in pg/L

Parameter	AP1-2 (industrial)	MI2-2* (industrial)	SR1-2 (old residential)	OR1-4 (new residential)
MonoPCB	10 UJ	**8.3**	**33.9**	10 UJ
DiPCB	**223.9**	**380.7**	**505.9**	**653.4**
TriPCB	**308.9**	**644.9**	**1586.6**	**1097.6**
TetraPCB	**418.6**	**521.6**	**2297.3**	**1504.8**
PentaPCB	**289.1**	**885.2**	**3779**	**1645**
HexaPCB	**370.1**	**1067**	**2785.5**	**1326.1**
HeptaPCB	**277.3**	**537**	**1241.2**	**920.1**
OctaPCB	**75.5**	**208.1**	**90.4**	**64.9**
NonaPCB	10 UJ	**193.3**	**46.4**	**46.5**
DecaPCB	10 UJ	**103**	10 UJ	**46.5**
Total PCB	**1963.4 J**	**4548.9 J**	**12366.2**	**7258.4**

** Average of two field replicates.*
***Bold** = Visual aid for detected compounds*
UJ = Estimated detection limit
B = Result less than five times blank contamination.

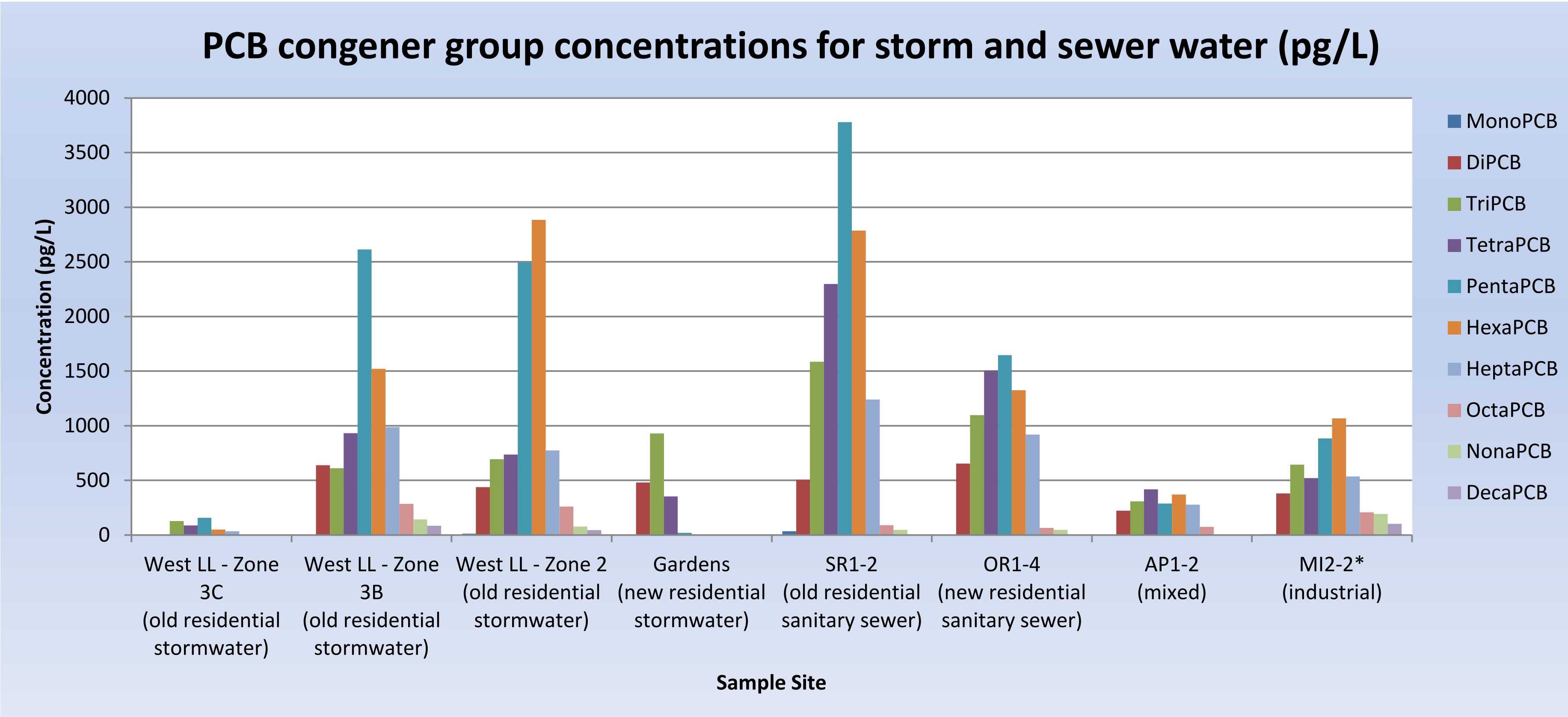

Figure 7. Comparison of stormwater and wastewater results for PCB homologue groups. ** Average of two field replicates.*

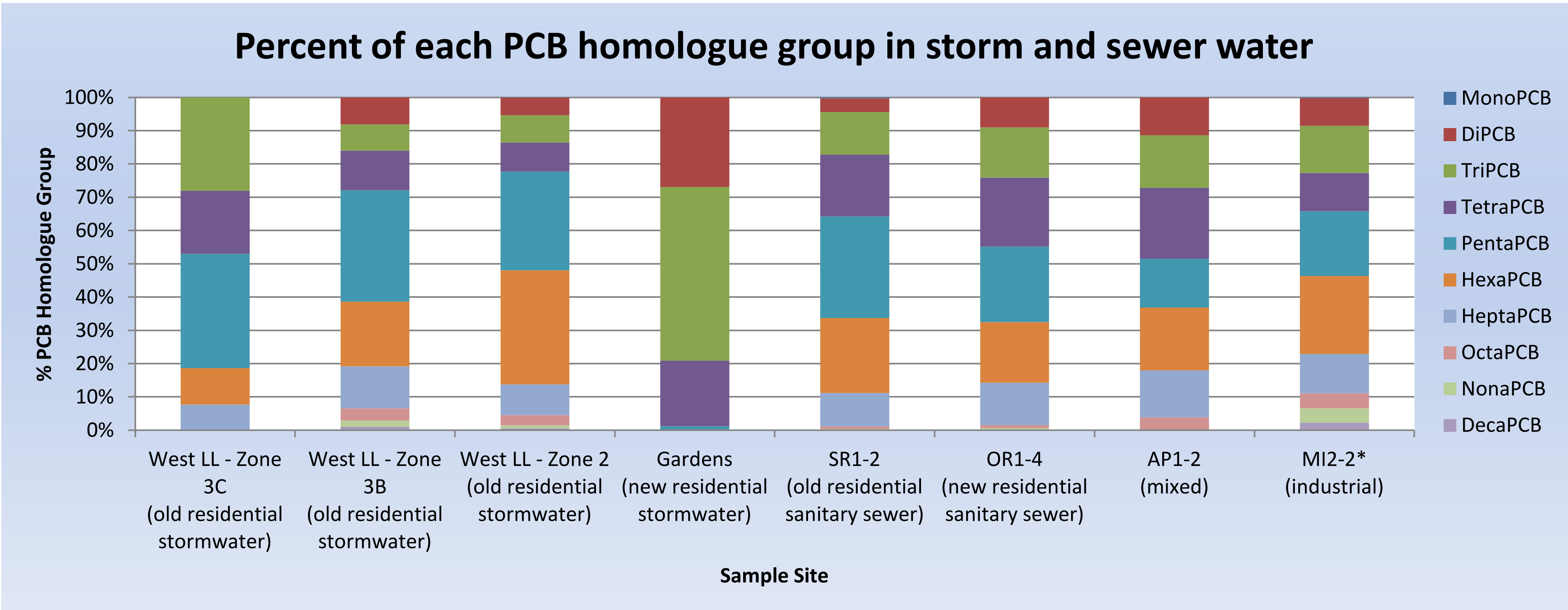

Figure 8. Comparison of the percent PCB homologue groups contributing to a sample of stormwater and wastewater. ** Average of two field replicates.*

Dioxin/Furan

We analyzed for the 17 co-planar congeners thought to be the most toxic forms, 10 furan and 7 dioxin compounds. We then calculated each site's Toxic Equivalency (TEQ) by summing the products of each congener result by the 2005 World Health Organization's (WHO) toxic equivalency factors (TEF) (Van den Berg et al., 2005). Ecology's Environmental Assessment Program guidance suggests all non-detect results be assigned as zero for purposes of summing and TEQ calculation (Table 16). For the purposes of providing all possible data for this report, table C-8 in Appendix C includes three calculated TEQs where the non-detected (ND) congeners, those flagged with a U or UJ, were included in the calculation as follows:

- ND = 0; lower bound
- ND = 1/2 detection limit; mid bound
- ND = detection limit; upper bound

Table C-8 includes all raw dioxin/furan data.

Table 16. Dioxin/Furan TEQs for the Liberty Lake study area

Site ID	2,3,7,8-TCDD TEQ (ND = 0)
Stormwater in pg/L	
Storm-Zone 2	2.70
Storm-Zone 3B	5.25
Storm-Zone 3C	1.61
Gardens	8.14
Storm-drain Sediment in ng/Kg dw	
*Alpine-Zone 1	9.09
Wright-Zone 2	2.10
Lilac-Zone 3	7.26
Wastewater in pg/L	
Influent Day	10.49
Influent Day	2.32
Influent Day**	6.40
Influent Night	0.22
AP1-2 (industrial)	1.54
MI2-2 (Industrial)	0.005
MI2-2 (Industrial)	0.062
MI2-2*** (Industrial)	0.034
SR1-2 (old residential)	1.86
OR1-4 (new residential)	0.187

** Composite*
***Average of duplicate*
****Average of replicate*

Storm-drain Sediment

Storm-drain dioxin/furan sediment concentrations for West LL ranged from 2.10 to 9.09 ng/Kg 2,3,7,8-TCDD TEQs (Table C-8). The Z2 sample was lower than the other two locations. It should be noted the drywell was under standing water and had a methane odor.

Ecology's Environmental Assessment Program provided a literature review of soil and sediment data reported within Washington State. Yake et al. (Yake et al. 2000) conducted a soil study test across Washington State by land use to determine the background concentrations of dioxin/furan. Our sediments were within the urban land use range of 0.13 – 19 units (Yake et al., 1998). The sediment Ecology sampled in Spokane storm-drains ranged from 0.065J to 17.71 ng/Kg for 2,3,7,8-TCDD TEQs (Parsons and Terragraphics Inc 2007).

Stormwater

All four stormwater samples showed some concentration of dioxin/furan. They ranged from 1.61 – 8.14 pg/L for 2,3,7,8-TCDD TEQ in (Table C-8). The samples with lower TEQs showed a much greater difference in the calculations between the upper and lower bound results. This is most likely a result of the number of congeners detected. It appears the higher TEQs are associated with more congeners detected per sample versus the same congeners at higher concentrations.

Wastewater

Wastewater concentrations had a wider range than stormwater, 0.005 – 10.49 pg/L for 2,3,7,8-TCDD TEQ in. The highest concentration was found in the daytime influent (6 a.m. – 6 p.m.) collected from the treatment plant.

Priority Pollutant Metals

Metals analysis included the 13 priority pollutant metals referenced in the Clean Water Act in section §307(a)(1) instead of just the select metals of concern (cadmium, lead, zinc). Metals data can be found in tables C-1 through C-3 in Appendix C.

Storm-drain Sediment

Arsenic, chromium, copper, lead, and nickel are elevated in the storm-drain sediment (Figures 9 and 10). This shows the same pattern seen in the stormwater.

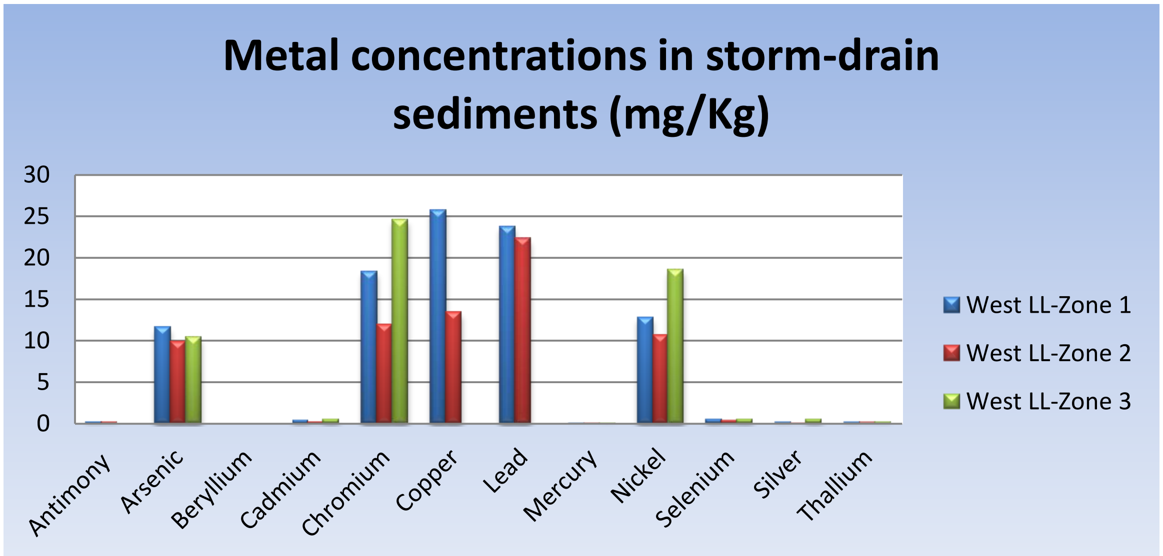

Figure 9. Total recoverable metal concentrations in storm-drain sediment.

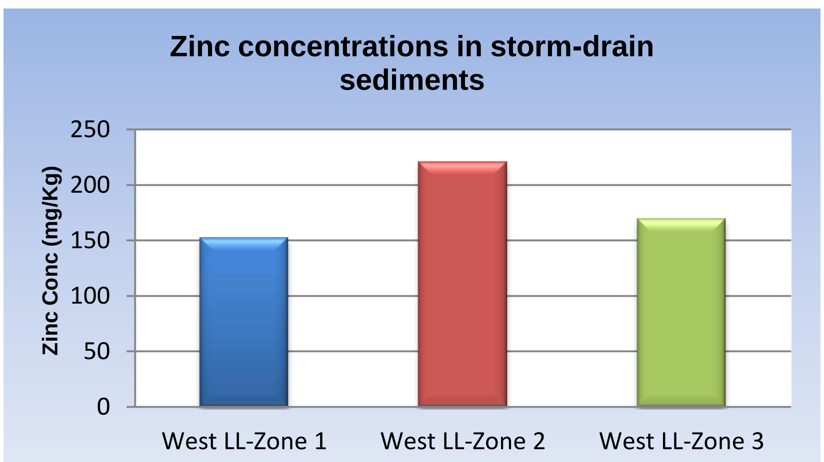

Figure 10. Total recoverable zinc concentrations in storm-drain sediment.

Stormwater

All of the 13 priority pollutant metals were detected in at least two sites except mercury, selenium, silver, and thallium (Figures 11 and 12). When averaged, the metal concentrations from the old residential areas exceeded the concentration from the new residential site for all metals detected except zinc (Figure 12, Table C-3). This may be the result of more galvanized materials being used and/or more tire wear on the asphalt in the newer neighborhood; however, the sample number is too low and further sampling will need to be conducted to determine the source. As a comparison, the industrial stormwater permit total zinc limit is 117 µg/L. The old residential sample is the only concentration to exceed that limit at 130 µg/L.

Arsenic, chromium, copper, lead, and nickel all show a higher concentration in the old residential neighborhood than the new (Figure 13). Cadmium is very low which may indicate residential neighborhoods are not a significant source of this metal to stormwater or the river. Further sampling is needed to confirm this theory.

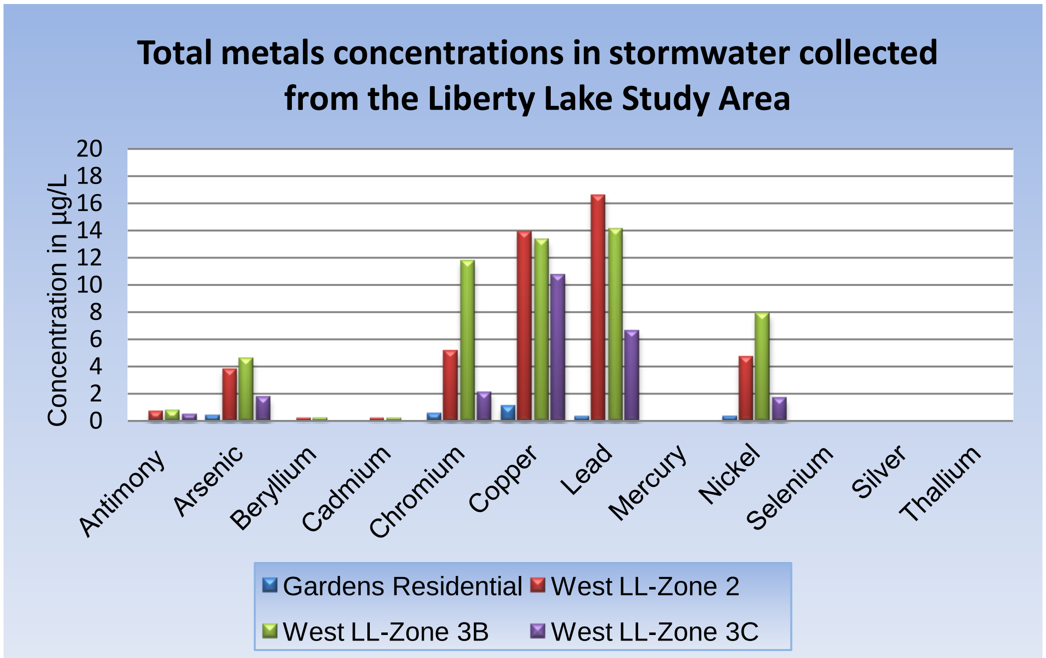

Figure 11. Total recoverable metals data for stormwater.

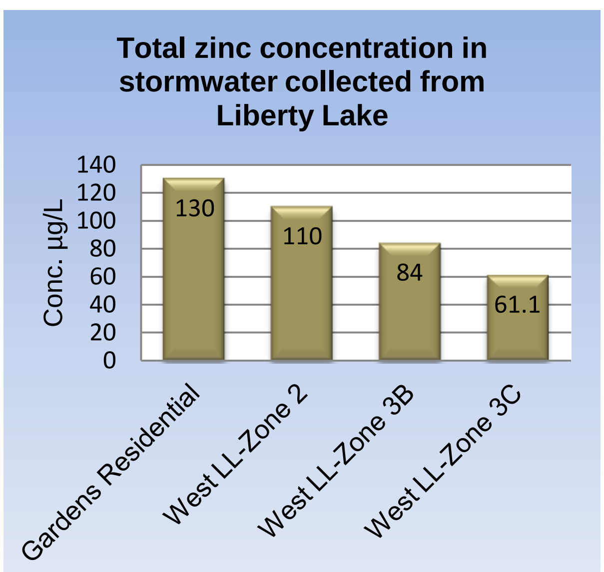

Figure 12. Total recoverable zinc concentrations in stormwater.

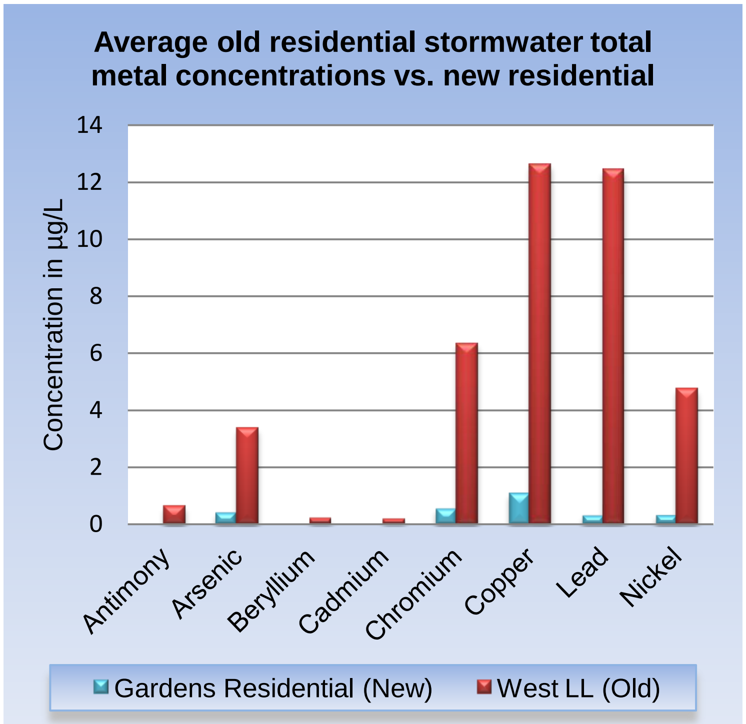

Figure 13. Comparison of old residential versus new residential metals concentrations.

Wastewater

Levels of copper, lead, mercury, nickel, selenium, silver, and zinc are generally higher in wastewater than in stormwater (Figures 14 and 15). All but thallium was present in at least one sample. Cadmium was present near the detection limit for all samples.

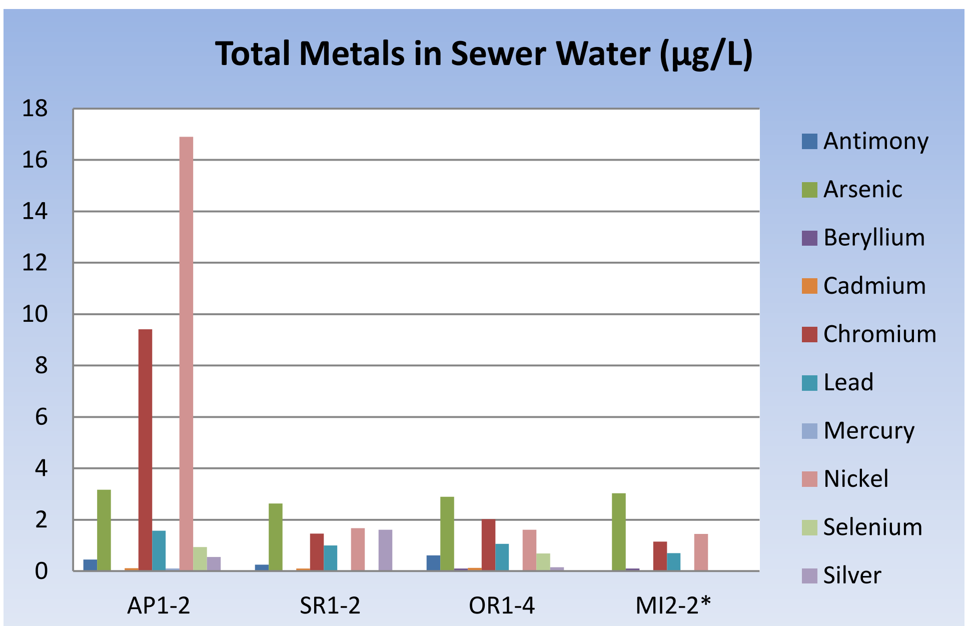

Figure 14. Total recoverable metal results for wastewater sample.

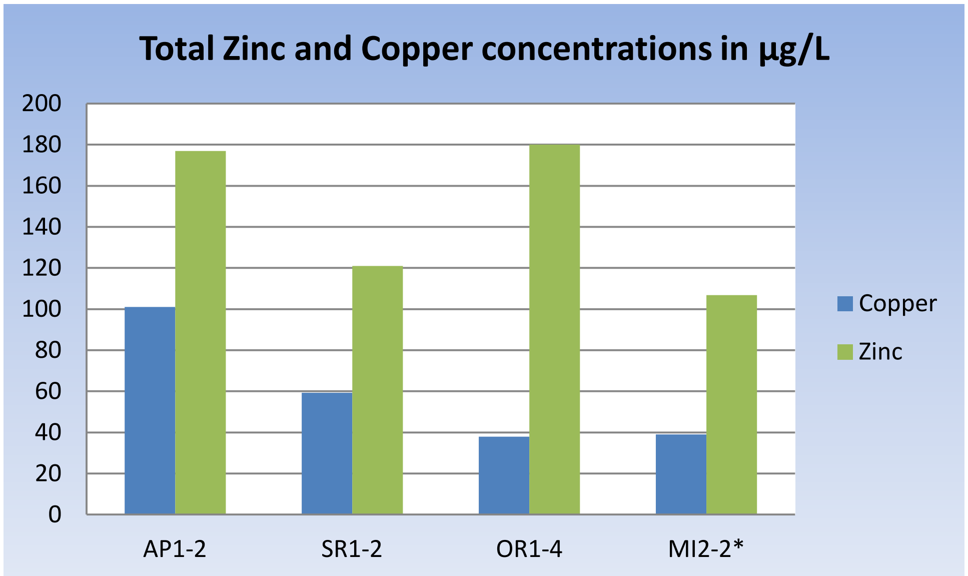

Figure 15. Total recoverable zinc and copper results for wastewater samples.

Phosphorus

Total phosphorus was collected to assist the Water Quality Program. Results can be found in the Appendix (Tables C-9 and C-10).

Business Visits

SRHD completed 20 initial business visits in the Liberty Lake study area. Two visits resulted in proper cleanup. At one location, the facility moved scrap metal, car batteries, and other automotive materials inside and under cover. This eliminated stormwater contact with metal-bearing materials, oils, and greases. Although not related to a particular CoC, the inspector also found oil contamination on gravel that ended in cleanup and proper disposal. The remaining visits resulted in occasional minor recommendations.

Conclusions

This study helped us gain a better understanding of urban concentrations in stormwater, storm-drain sediment, and wastewater within the Liberty Lake area; however, the number of samples taken will not provide us with a statistically-based representative urban 'background' concentration.

All CoC were found in all media.

- Wastewater and stormwater ranges for organic CoC have similar pattern: PBDE (ppb) > PCB (ppt) > Dioxin/Furan (ppq)
- Storm-drain sediment range for organic CoC (ppb): PBDE ≈ PCB > Dioxin/Furan
- All media ranges have similar pattern for CoC metals: zinc > lead > cadmium

PBDE
- Higher in wastewater than stormwater.
- Stormwater contribution is not always reflected in storm-drain sediment.

PCB
- Similar in wastewater and stormwater.
- Similar concentrations to PBDE in sediment.
- Higher in residential wastewater than mixed industrial wastewater.
- Higher in old residential wastewater than new residential.

Dioxin/Furan
- Higher in stormwater than wastewater.
- Highest concentration in new residential stormwater.

Cadmium
- Similar in wastewater and stormwater.
- Higher in old residential stormwater than new residential stormwater.

Lead
- Higher in stormwater than wastewater.
- Higher in old residential stormwater than new residential stormwater.

Zinc
- Slightly higher in wastewater than stormwater.
- Higher in new residential stormwater than old residential stormwater.

Other Conclusions

- Sampling methods were validated and possible areas of contamination were determined. PBDE contamination found in our blanks may be due to glassware, mixing container, or blank water contamination. We will continue to run blanks to isolate and help determine the cause. This will include labware blanks and rinsate blanks along with our standard blanks. PCB contamination in the rinsate showed decontamination procedures may need to be more thorough. We are considering adding an additional acetone rinse. According to Pacific Rim, often times PCB blank contamination is from sample bottles received from the lab instead of the water, but neither can be ruled out at this point.

- Dioxin/furan are detectable in wastewater and stormwater using EPA Method 1613B. This finding can be used to detect this contaminant in stormwater outfalls and for in-line branch source tracing in wastewater and stormwater pipes if sediment collection is not possible.

- Additional safety equipment should be purchased to perform sampling on busy thoroughfares. LLSWD provided staff and equipment to safely sample on Appleway Ave.

Recommendations

Source Identification

All contaminants were found in residential stormwater and wastewater at low levels. Further outfall and wastewater sampling will determine whether the hydrology of the Spokane River in combination with point and non-point sources explain some of our elevated levels compared to the rest of Washington State, especially for PBDE. Hydrologic features such as aquifer interchange and decreased channel flow around Nine Mile and Lake Spokane may be a factor. River sediment movement and the affects of aquifer water chemistry and temperature would be useful information for understanding our CoC issues.

More data is needed to determine whether we should continue sampling TSS, TOC, TDS, and DOC in water to assist with source tracing. Additional comparisons such as congener patterns may be useful in determining a source.

Total PBDE have a large range of values for stormwater and wastewater. The large PBDE wastewater range may indicate a source from wastewaters from new residential neighborhoods, but more data is needed.

PBDEs

- Finding PBDE-209 in some stormwater samples indicates there may be a current source of PBDE from residential neighborhoods. ATSDR says if PBDE-209 is present, we are most likely near a source (ATSDR 2004). The detection limit for stormwater PBDE-209 for Ecology's 2007 study (Parsons and Terragraphics Inc 2007) was two times as high as those for this study (~0.050 µg/L vs. ~0.025 µg/L respectively). One sample collected for this study was below the detection limit of the previous study indicating the previous studies PBDE-209 detection limit may have prevented it from identifying an outfall for up-the-pipe source tracing.

- Results from this study suggest drainage catchments in Spokane that differ in their age and paved surface areas should be investigated for clues to source identification.

- Sampling of wastewater treatment plant effluent will be important in determining how much of a source they are to the river.

- Air deposition may be a cause of stormwater contamination and future sampling should focus on determining the contribution of this non-point source.

- Broaden idea of source tracing to include the following:
  - Better understand river sediment movement and aquifer chemistry effects on CoC movement in the river to better understand the link of fish tissue concentrations to source location.
  - Sample more outfalls multiple times to increase accuracy and determine seasonal variation.

- ➢ Focus on wastewater sources to reduce concentration in influent, mostly residential (education) and possibly business sectors associated with residential work (laundromats, carpet cleaners, furniture shops, re-upholsterers, etc.).
- ➢ Determine influence of local and long-range air deposition on stormwater collection systems and river concentrations.

PCB

- PCB were found everywhere, but at low levels. The Parsons and Terragraphics 2007 stormwater study showed several basins at substantially higher concentrations including CSO34 and Union Basin. We should begin our source tracing efforts in these basins.

Dioxin/Furan

- If future Spokane sampling results are found to be similar to this study's results, then overall concentrations will be within the typical background range for Washington State (Yake et al 2000). We may need to focus on river hydrology if that is the case.

- Include influent and effluent monitoring for dioxin/furan during large storm events and the rainy seasons in the city of Spokane's wastewater treatment plant permit. Sampling indicated stormwater may be a larger source than wastewater for this contaminant.

Metals

- Zinc may be more of an issue in newer residential neighborhoods. We noted more galvanized housing materials and paved surface area that could increase tire wear. One focus for future sampling should be on building materials and to continue looking at newer residential neighborhoods to understand their relative contributions.

- Industrial areas should still be sampled for source identification.

General Recommendations

- More data points are needed to increase confidence in the results, better define variability of target contaminants, and to determine background urban concentration ranges.

- Turbidity should be included in field measurements when collecting stormwater samples to assist with source tracing.

- Hardness will also need to be collected in conjunction with metals analysis to assist with determining compliance with the Water Quality Standards.

- Develop and validate an in-line sediment trap for stormwater to collect data over time. We have begun testing an in-line storm-sediment trap that may produce a better picture of the overall contribution from a catchment for those contaminants that adsorb to particulates. This would enhance the water sampling, but it will not be a replacement. Previous semi-permeable membrane device sampling in the Spokane River along with other studies from around the world show congeners within a particular contaminant group have variable physicochemical characteristics thus some will adsorb to sediment while others will remain in the dissolved phase under the same conditions. In turn, variable conditions within the same catchment (new source release, changing acidity, other contaminants, TSS, TOC) may alter where a congener partitions from one storm or flush to the next.

- Purchase a separate, large capacity refrigerator in a designated space where hazardous chemicals are acceptable to store. The refrigerator in the Sample Prep room froze our sediment samples and does not have the storage capacity we need for large volumes of samples. This location also does not allow hazardous material storage (e.g., acetone, nitric acid).

- Develop agreement with jurisdictional local authority for assistance with confined spaced entry work for sediment collection in pipes when necessary.

- Purchase additional safety equipment for working on busy thoroughfares (cones, vehicle flashing utility light, reflective rain gear, directional or 'Men at Work' signs).

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Appendices

Appendix A. Glossary, Acronyms, Abbreviations, and Units of Measurement

Glossary

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the Total Maximum Daily Load (TMDL) program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and watercourses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

CoC	Contaminant of concern
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System software
MEL	Manchester Environmental Laboratory
NPDES	(See Glossary above)
PBDE	polybrominated diphenyl ethers
PCB	polychlorinated biphenyls
PBT	persistent, bioaccumulative, and toxic substance
RPD	Relative percent difference

TDS	Total dissolved solids
TMDL	(See Glossary above)
TOC	Total organic carbon
TSS	Total suspended solids
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resources Inventory Area
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
dw	dry weight
ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams.
mg	milligrams
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mL	milliliters
ng/Kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units
pg/L	picograms per liter (parts per quadrillion)
µg/Kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µm	micrometer
umhos/cm	micromhos per centimeter

Appendix B. Figures

Figure B- 1. Wastewater sampling locations.

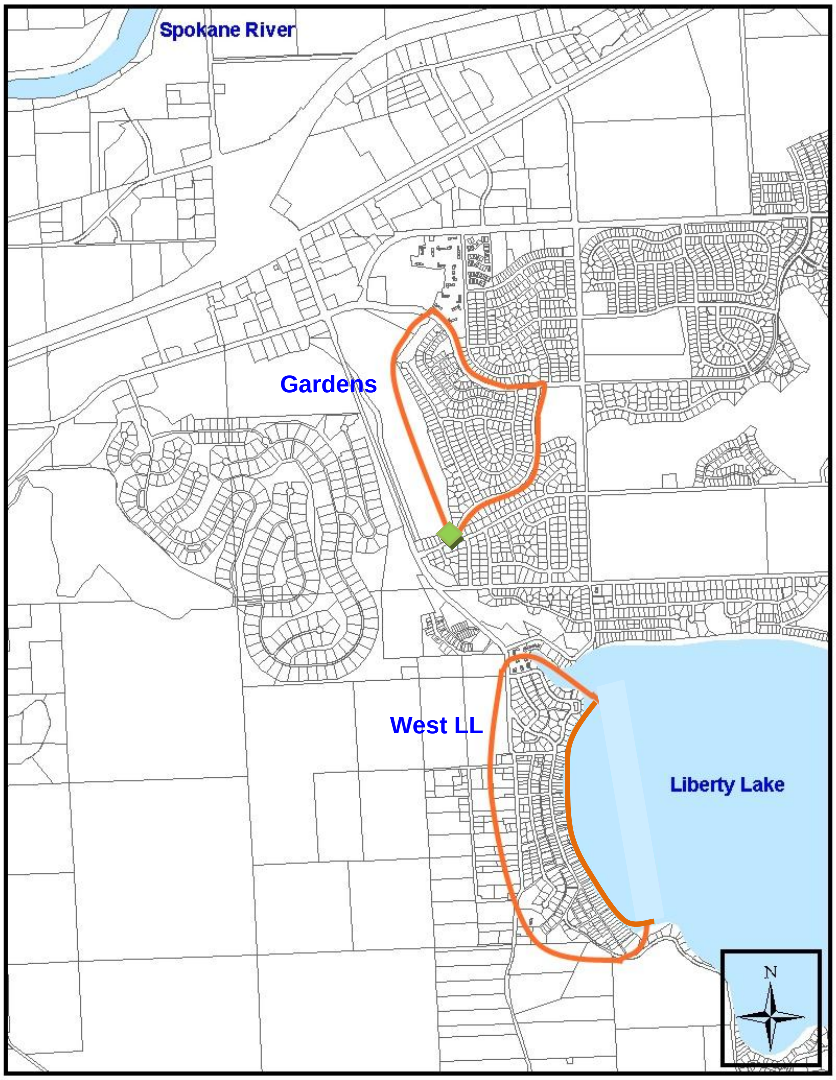

Figure B- 2. Drainage area of piped stormwater systems in Liberty Lake study area. The Garden system collection point is marked with a ◆.

Figure B- 3. WestLL stormwater sampling subbasins. Stormwater sample locations are marked with a ◆.

Figure B- 4. WestLL storm-drain sampling locations for Zone 1 (Z1) and Zone 2. Stormwater sampling location for Zone 2 same as storm-drain location.

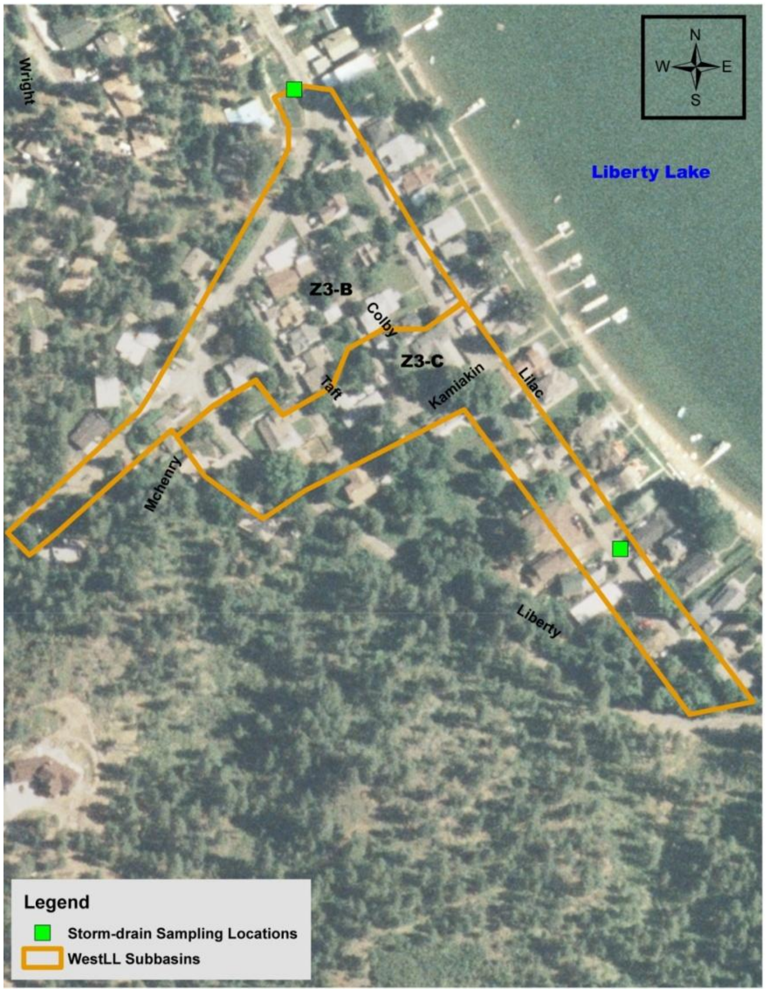

Figure B- 5. WestLL storm-drain sampling locations for Zone 3 (Z3). Same locations as stormwater samples.

Appendix C. Contaminant Data

Table C-1. Total recoverable metal results for storm-drain sediment in mg/Kg

Site ID	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
West LL-Zone 1	0.19	11.6	0.44 J	0.42	18.3	25.7	23.8	0.026	12.8	0.5	0.16	0.16	152
West LL-Zone 2	0.16	9.87	0.42 J	0.18	12	13.4	22.3	0.014	10.7	0.38	0.064	0.12	220
West LL-Zone 3	0.3 J	10.4	0.49 J	0.508	24.6	43.8 J	43.1 J	0.055	18.5	0.49	0.49	0.14	169

J = Result is an estimate

Table C-2. Total recoverable metal results for wastewater in µg/L

Site ID	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
AP1-2	**0.45**	**3.17**	0.10 U	**0.12**	**9.41**	**101**	**1.58**	**0.101**	**16.9**	**0.94**	**0.56**	0.10 U	**177**
SR1-2	**0.25**	**2.64**	0.10 U	**0.10**	**1.47**	**59.3**	**1.00**	0.05 U	**1.67**	0.50 U	**1.61**	0.10 U	**121**
OR1-4	**0.62**	**2.90**	**0.10 J**	**0.13**	**2.03**	**37.9**	**1.06**	0.05 U	**1.61**	**0.69**	**0.15**	0.10 U	**180**
MI2-2 Rep	0.2 U	**3.00**	0.10 U	0.10 U	**0.82**	**32.7**	**0.45**	0.05 U	**1.00**	0.50 U	0.10 U	0.10 U	**77.7 J**
MI2-2	**0.53**	**3.07**	**0.10 J**	**0.12**	**1.48**	**45.3**	**0.95**	0.05 U	**1.90**	**0.58**	0.10 U	0.10 U	**136**

*Rep = replicate U = Not detected at the sample quantitation limit shown J = Result is an estimate **Bold** = Visual aid for detected compounds*

Table C-3. Total recoverable metal results for stormwater in µg/L

Site ID	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
WestLL-Zone 2	**0.69**	**3.82**	**0.18**	**0.18**	**5.12**	**13.9**	**16.6**	0.05 U	**4.69**	0.5 U	0.1 U	0.1 U	**110**
WestLL-Zone 3B	**0.72**	**4.57**	**0.19**	**0.16**	**11.8**	**13.3**	**14.1**	0.05 U	**7.9**	0.5 U	0.1 U	0.1 U	**84**
WestLL-Zone 3C	**0.48**	**1.74**	0.1 U	0.1 U	**2.1**	**10.7**	**6.62**	0.05 U	**1.66**	0.5 U	0.1 U	0.1 U	**61.1**
Gardens	0.2 U	**0.41**	0.1 U	0.1 U	**0.55**	**1.09**	**0.31**	0.05 U	**0.33**	0.5 U	0.1 U	0.1 U	**130**

*U = Not detected at the sample quantitation limit shown **Bold** = Visual aid for detected compounds*

Table C-4. PBDE storm-drain sediment composite results for West LL in µg/Kg DW. Those values qualified as U and UJ are not reflected in calculated totals.

PBDE Congener	West LL-Zone 1	West LL-Zone 2	West LL- Zone 3
PBDE-47	**3.8**	0.27 U	**3.2**
PBDE-49	0.26 U	0.27 U	0.77 U
PBDE-66	0.26 U	0.27 U	0.77 U
PBDE-71	0.26 U	0.27 U	0.77 U
PBDE-99	**5.5**	0.27 U	**2.7**
PBDE-100	**1.6**	0.27 U	0.77 U
PBDE-138	0.52 U	0.54 U	1.5 UJ
PBDE-153	0.52 U	0.54 U	1.5 U
PBDE-154	0.52 U	0.54 U	1.5 U
PBDE-183	0.52 U	0.54 U	1.5 U
PBDE-184	0.52 U	0.54 U	1.5 U
PBDE-191	0.52 U	0.54 U	1.5 U
PBDE-209	6.5 U	6.8 U	19.2UJ
PBDE total	**10.9**	6.8 U	**5.9**

Bold *= Visual aid for detected compounds* *U = Not detected at the sample quantitation limit shown*
UJ = Estimated detection limit

Table C-5. PBDE stormwater results in µg/L

Parameter	West LL-Zone 2	West LL-Zone 3B	West LL-Zone 3C	Gardens
PBDE- 47	**0.0022**	**0.0058**	0.001 U	**0.0008 J**
PBDE- 49	0.001 U	0.001 U	0.001 U	0.001 U
PBDE- 66	0.001 U	0.001 U	0.001 U	0.001 U
PBDE- 71	0.001 U	0.001 U	0.001 U	0.001 U
PBDE- 99	0.0016 B	0.0027 B	0.0007 B	0.0005 B
PBDE-100	0.001 U	0.001 U	0.001 U	0.001 U
PBDE-138	0.002 U	0.002 U	0.004 U	0.002 U
PBDE-153	0.002 U	0.002 U	0.002 U	0.002 U
PBDE-154	0.002 U	0.002 U	0.002 U	0.002 U
PBDE-183	0.002 U	0.002 U	0.002 U	0.002 U
PBDE-184	0.002 U	0.002 U	0.004 U	0.002 U
PBDE-191	0.002 U	0.002 U	0.004 U	0.002 U
PBDE-209	**0.046**	0.025 U	**0.073**	0.027 U
PBDE total	**0.0482 J**	**0.0058 J**	**0.073**	**0.0008 J**

Bold *= Visual aid for detected compounds* *U = Not detected at the sample quantitation limit shown*
UJ = Estimated detection limit *J = Result is an estimate*
B = Result less than five times blank contamination.

Table C-6. PBDE results for Liberty Lake Sewer and Water District wastewater treatment plant influent 12-hour composite samples and in-line wastewater samples in µg/L

Parameter	Influent Day	Influent Day Rep	*Influent Day	Influent Night	AP1-2	MI2-2	MI2-2 Rep.	MI2-2*	OR1-4	SR1-2
PBDE-47	**0.044 J**	**0.041 J**	---	**0.042 J**	**0.02**	**0.072**	**0.027**	---	**0.27 J**	**0.11 J**
PBDE-49	0.001 UJ	0.001 UJ	---	0.001 UJ	0.004 U	0.004 U	0.004 U	---	**0.006 J**	**0.003 J**
PBDE-66	0.001 UJ	0.001 UJ	---	0.001 UJ	0.004 U	0.004 U	0.004 U	---	0.004 UJ	0.004 UJ
PBDE-71	0.001 UJ	0.001 UJ	---	0.001 UJ	0.004 U	0.004 U	0.004 U	---	0.004 UJ	0.004 UJ
PBDE-99	**0.041 J**	**0.037 J**	---	**0.042 J**	**0.02**	**0.077**	**0.029**	---	**0.25 J**	**0.11 J**
PBDE-100	**0.0094 J**	**0.01 J**	---	**0.0076 J**	**0.003 J**	**0.015**	**0.005**	---	**0.045 J**	**0.02 J**
PBDE-138	0.002 UJ	0.002 UJ	---	0.002 UJ	0.009 U	0.009 U	0.008 U	---	0.008 UJ	0.009 UJ
PBDE-153	**0.0053 J**	**0.005 J**	---	**0.0044 J**	0.009 U	**0.01**	**0.003 J**	---	**0.024 J**	**0.012 J**
PBDE-154	**0.0034 J**	**0.0038 J**	---	**0.003 J**	**0.003 J**	**0.007 J**	**0.004 J**	---	**0.014 J**	**0.009 J**
PBDE-183	**0.00053 J**	**0.00051 J**	---	0.002 UJ	0.009 U	0.009 U	0.008 U	---	0.008 UJ	0.009 UJ
PBDE-184	0.002 UJ	0.002 UJ	---	0.002 UJ	0.009 U	0.009 U	0.008 U	---	0.008 UJ	0.009 UJ
PBDE-191	0.002 UJ	0.002 UJ	---	0.002 UJ	0.009 U	0.009 U	0.008 U	---	0.008 UJ	0.009 UJ
PBDE-209	**0.052 J**	**0.048 J**	---	**0.04 J**	**0.27**	**0.081**	**0.024**	---	**0.47 J**	**0.091 J**
PBDE Total	**0.156 J**	**0.145 J**	**0.152 J**	**0.139 J**	**0.316 J**	**0.262**	**0.092**	**0.177**	**1.079 J**	**0.355 J**

Mean of field replicates* **Bold *= Visual aid for detected compounds* *U = Not detected at the sample quantitation limit shown*
Rep = replicate *UJ = Estimated detection limit* *J = Result is an estimate*

Table C-7. PCB results

IUPAC	West LL - Zone 1	West LL - Zone 2	West LL - Zone 3	West LL - Zone 3C	West LL -Zone 3B	West LL - Zone 2	Gardens	SR1-2	OR1-4	AP1-2	MI2-2	MI2-2 Rep.
	Sediment (ug/Kg)			Stormwater (pg/L)				Wastewater (pg/L)				
PCB-001	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10.6 B	10 U	17.7 B	16 B	10 UJ	10 UJ	10 UJ
PCB-002	0.003 U	0.003 U	**0.0078**	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-003	0.003 U	0.003 U	**0.0065**	10 UJ	10 UJ	**11.1**	10 U	**33.9**	10 UJ	10 UJ	10 UJ	**16.5**
PCB-004	0.01 U	0.01 U	0.01 U	10 UJ	10 UJ	21.6 B	27.2 B	47.8 B	46.3 B	10 UJ	24.6 B	16.7 B
PCB-005/008	0.01 U	0.0101 B	0.0242 B	11.7 B	87.4 B	118 B	95.4 B	187 B	155 B	49.3 B	104 B	30 B
PCB-006	0.01 U	0.01 U	0.01 U	10 UJ	**13.9**	**18.6**	10 U	**52.6**	**72.2**	**15.5**	**28.4**	**15.5**
PCB-007	0.01 U	0.01 U	0.01 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	**15.4**	10 UJ	10 UJ
PCB-009	0.01 U	0.01 U	0.01 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-010	0.01 U	0.01 U	0.01 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-011	0.178 B	0.117 B	0.449 B	68.6 B	**533**	**327**	**357**	**381**	**559**	**167 J**	**462**	**200 J**
PCB-012/013	0.01 U	0.01 U	0.01 U	10 UJ	**11.2**	10 UJ	**10.2**	10 UJ	**22.2**	10 UJ	10 UJ	10 UJ
PCB-014	0.01 U	0.01 U	0.01 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-015	**0.0131**	**0.0144**	**0.0498**	10 UJ	**80.4**	**92.7**	**114**	**72.3**	10 UJ	**26**	**40.6**	**14.9**
PCB-016	0.0058 B	0.008 B	0.004 U	15.1 B	54.7 B	26.1 B	**64.5 J**	**83.6**	**57.2**	**23.1**	**73.1**	**12.2**
PCB-017	0.0058 B	0.0077 B	0.0118 B	10 UJ	**31.7**	**30.5**	**44.2**	**76.8**	**56.8**	**14.9**	**48.5**	10 UJ
PCB-018	0.0166 B	0.021 B	0.0419 B	20.9 B	70.3 B	79.5 B	**112 J**	**189**	**150**	49.4 B	**142 J**	10 UJ
PCB-019	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-020/033	0.0116 B	0.0204 B	0.0348 B	**20.3**	**103**	**123**	**125**	**247**	**168**	**53.1**	**139**	**41**
PCB-021	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-022	0.0072 B	0.0139 B	0.0276 B	**18**	**66.9**	**79.2**	**82.4**	**141**	**97.7**	**29.8**	**88.4**	10 UJ
PCB-023	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-024	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-025	0.004 U	0.004 U	0.004 U	10 UJ	**12.6**	**14.5**	**20.8**	**25.7**	**18.3**	10 UJ	10 UJ	**52.2**
PCB-026	0.004 U	**0.0042**	0.004 U	10 UJ	**20.8**	**21.8**	**24**	**51.5**	**27.7**	**10.7**	**29.7**	10 UJ
PCB-027	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-028	0.0162 B	0.0268 B	0.0573 B	**41**	**166**	**201**	**231**	**315**	**208**	**71.7**	**194**	12 UJ
PCB-029	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-030	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-031	0.0145 B	0.0251 B	0.0466 B	**32.5**	**137**	**151**	**179**	**312**	**198**	**64.6**	**192**	**48.2**
PCB-032	**0.0043**	**0.0085**	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	**49.4**	**14.8**	**53.3**	10 UJ
PCB-034	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-035	0.004 U	0.004 U	**0.0099**	10 UJ	**14.1**	10 UJ	10 U	10 UJ	10 UJ	10 UJ	**136**	10 UJ
PCB-036	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	**40.1**	10 UJ
PCB-037	0.0156 B	**0.0316 J**	**0.0545**	**16.8**	**59.4**	**71.9**	**47.5**	**145**	**66.5**	**26.2**	10 UJ	10 UJ

IUPAC	West LL - Zone 1	West LL - Zone 2	West LL - Zone 3	West LL - Zone 3C	West LL -Zone 3B	West LL - Zone 2	Gardens	SR1-2	OR1-4	AP1-2	MI2-2	MI2-2 Rep.
	Sediment (ug/Kg)			Stormwater (pg/L)				Wastewater (pg/L)				
PCB-038	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-039	0.004 U	0.004 U	0.004 U	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-040	**0.0051**	**0.0113**	0.003 UJ	10 UJ	**19.7**	10 UJ	10 U	10 UJ	**24.6**	**13**	10 UJ	10 UJ
PCB-041	0.003 U	**0.0043**	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	**23.9**	**12.6**	10 UJ	10 UJ	10 UJ
PCB-042	**0.0059**	**0.0128**	0.003 UJ	10 UJ	**29.6**	**30.2**	10 U	**47.9**	**44.6**	**13.9**	10 UJ	10 UJ
PCB-043/049	0.0158 B	0.0334	**0.0616 J**	10 UJ	**81.7**	**67.8**	**49.2**	**210**	**146**	**36.8**	**84.3**	10 UJ
PCB-044	0.0285 B	**0.0619 J**	**0.107**	**25.3**	**118**	**104**	**62.1**	**302**	**201**	**58.2**	**109**	**51.4**
PCB-045	**0.0042**	**0.0071**	0.003 U	10 UJ	**16.6**	10 UJ	10 U	**39.6**	**28**	10 UJ	**20.5**	10 UJ
PCB-046	0.003 U	**0.0037**	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	**14.1**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-047/048	0.0043 B	0.008 B	0.0142 B	10 UJ	**26.6**	**24.4**	**19.7**	**82.1**	**65.1**	**21.8**	**45.8**	10 UJ
PCB-050	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-051	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	**20**	**23.1**	10 UJ	10 UJ	10 UJ
PCB-052/069	0.0402 B	**0.0829 J**	0.003 UJ	32.1 B	**145**	**112**	**65.1 J**	**434**	**265**	**73.2**	**145**	**74.1**
PCB-053	**0.0047**	**0.0073**	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	**25.9**	10 UJ	10 UJ	10 UJ
PCB-054	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-055	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-056	**0.0282**	**0.0503**	0.003 UJ	**12.9**	**58.3**	**58.1**	**11.4**	**87.8**	**38.6**	**17.4**	**34.7**	10 UJ
PCB-057	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-058	**0.0051**	**0.0033**	**0.0204**	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-059	0.003 U	**0.0045**	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-060	**0.0142**	**0.026**	0.003 UJ	10 UJ	10 UJ	**30.7**	10 U	**58.8**	**54.3**	**17.1**	**19.1**	10 UJ
PCB-061	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-062	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-063	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-064/072	0.0137 B	**0.0317 J**	**0.0563**	**12.4**	**61.5**	**49.7**	**27.6**	**108**	**73.2**	**26.5**	10 UJ	10 UJ
PCB-065/075	0.003 U	0.003 U	0.003 UJ	10 UJ	**26.6**	**24.4**	**19.5**	**82.1**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-066	0.0299 UJ	**0.08**	**0.095**	**24.3**	**93.3**	10 UJ	**28.7**	**182**	**129**	**38.9**	**55.1**	**99.4**
PCB-067	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-068	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-070	0.0407 B	**0.118**	**0.135**	10 UJ	**152**	**151**	**46.5**	**364**	**206**	**51.3**	**74.3**	**113**
PCB-071	**0.0069**	**0.0152**	**0.0289**	10 UJ	**31.2**	10 UJ	10 U	**61.5**	**40.1**	**12.9**	10 UJ	10 UJ
PCB-073	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-074	0.0125 B	**0.0371**	**0.0404**	**12.1**	**51.2**	**53.3**	**23**	**162**	**114**	**37.6**	**47.1**	**70.4**
PCB-076	0.003 U	**0.003**	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-077	**0.0177**	**0.0332**	**0.0304**	10 UJ	**20.1**	**29.9**	10 U	**17.5**	**13.7**	10 UJ	10 UJ	10 UJ

IUPAC	West LL - Zone 1	West LL - Zone 2	West LL - Zone 3	West LL - Zone 3C	West LL -Zone 3B	West LL - Zone 2	Gardens	SR1-2	OR1-4	AP1-2	MI2-2	MI2-2 Rep.
	Sediment (ug/Kg)			Stormwater (pg/L)				Wastewater (pg/L)				
PCB-078	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-079	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-080	0.003 U	0.003 U	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-081	**0.0047**	**0.0103**	0.003 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-082	**0.0289**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	**58.7**	10 U	**62.7**	**65.2**	10 UJ	10 UJ	10 UJ
PCB-083	**0.0113**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-084	**0.0263**	**0.0648**	**0.0618**	10 UJ	10 UJ	**54.2**	10 U	**95.5**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-085	**0.0414**	0.03 UJ	0.03 UJ	10 UJ	**85.9**	**64**	10 U	**71.6**	**31.2**	10 UJ	10 UJ	10 UJ
PCB-086/097/117	**0.0587**	**0.149**	**0.17**	10 UJ	**121**	**123**	10 U	**167**	**97.4**	10 UJ	10 UJ	**76.8**
PCB-087/115	**0.0658**	**0.184**	**0.194**	**18.2**	**133**	**133**	10 U	**217**	**115**	10 UJ	**53.5**	10 UJ
PCB-088	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-089	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-090	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	**182**
PCB-091	**0.0306**	0.03 UJ	**0.129**	10 UJ	10 UJ	**54.8**	10 U	**62.6**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-092	**0.086**	**0.134**	**0.247**	10 UJ	**117**	10 UJ	10 U	10 UJ	**56.2**	10 UJ	10 UJ	10 UJ
PCB-093/095/098/102	**0.162**	**0.366**	**0.678**	39.3 B	**355**	**321**	25.1 B	**515**	**247**	**73 J**	**96.1 J**	**78 J**
PCB-094	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-096	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-099	**0.0566**	**0.156**	**0.17**	**18.5**	**113**	**134**	10 U	**229**	**119**	10 UJ	**29.4**	10 UJ
PCB-100	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-101	**0.154**	**0.382**	**0.44**	49.5 B	**315**	**329**	43.3 B	**632**	**253**	**85.7**	**116**	**174**
PCB-103	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	**41.6**	10 UJ	10 UJ	10 UJ
PCB-104	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-105	**0.0838**	**0.208**	**0.186**	**22.7**	10 UJ	**185**	10 U	**163**	**59**	**38.2**	**75.5**	**82.8**
PCB-106	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-107/108	**0.0143**	0.03 UJ	**0.0328**	10 UJ	10 UJ	**26.2**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-109	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-110	**0.334**	**0.754**	**1.14**	**60.2 J**	**572**	**658**	29.4 B	**514**	**202**	10 UJ	**97.8**	**170**
PCB-111	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-112/119	**0.0034**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	**22.5**	10 UJ	10 UJ	10 UJ
PCB-113	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-114	**0.0061**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	**11**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-116/125	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-118	**0.149**	**0.359**	**0.33**	**37.7**	**223**	**329**	**20.9**	**432**	**186**	**92.2**	**160**	**231**

IUPAC	West LL - Zone 1	West LL - Zone 2	West LL - Zone 3	West LL - Zone 3C	West LL -Zone 3B	West LL - Zone 2	Gardens	SR1-2	OR1-4	AP1-2	MI2-2	MI2-2 Rep.
	Sediment (ug/Kg)			Stormwater (pg/L)				Wastewater (pg/L)				
PCB-120	0.003 U	0.03 UJ	0.03 UJ	10 UJ	**578**	10 UJ	10 U	**520**	10 UJ	10 UJ	**98.8**	10 UJ
PCB-121	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	**45**	**18.6**	10 UJ	10 UJ	10 UJ
PCB-122	**0.0038**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-123	**0.0043**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	**30.4**	**90.5**	10 UJ	**21.3**	10 UJ
PCB-124	**0.0072**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	**15.3**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	**11.6**
PCB-126	**0.0056**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	**22.2**	**40.8**	10 UJ	**15.8**	10 UJ
PCB-127	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-128	**0.121**	0.03 UJ	**0.264**	**11**	**123**	**193**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	**49.5**
PCB-129	**0.0196**	**0.0393**	0.03 UJ	10 UJ	**38.1**	**37.7**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-130	**0.0281**	**0.0482**	**0.0738**	10 UJ	10 UJ	**50.8**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	**25.1**
PCB-131	**0.0058**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-132	**0.17**	0.03 UJ	**0.421**	**26.8**	**179**	**265**	10 U	**202**	**64.9**	10 UJ	**66.7**	**43.1**
PCB-133	**0.0046**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-134	**0.0198**	0.03 UJ	**0.0518**	10 UJ	10 UJ	**34.8**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-135	**0.0526**	**0.0633**	**0.144**	10 UJ	10 UJ	**57.4**	10 U	**54**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-136	**0.0509**	0.03 UJ	**0.153**	10 UJ	**54.4**	**62**	10 U	**79.2**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-137	**0.0242**	**0.0412**	0.03 UJ	10 UJ	10 UJ	**47.2**	10 U	**29.9**	**16.8**	10 UJ	10 UJ	**26.2**
PCB-138	**0.331**	**0.585**	**0.757**	51.8 B	**384**	**657**	26.6 B	**522**	**259**	**128**	**175**	**357**
PCB-139/149	**0.334**	**0.425**	**0.903**	45.5 B	13 UJ	**425**	39.6 B	**501**	**199**	**70.7**	**186**	**191**
PCB-140	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-141	**0.0629**	**0.0851**	**0.137**	10 UJ	**68.7**	**82.1**	10 U	**94.8**	**27.2**	10 UJ	10 UJ	10 UJ
PCB-142	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-143	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-144	**0.0158**	0.03 UJ	**0.051**	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-145	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-146	**0.0532**	**0.0648**	0.03 UJ	10 UJ	**59.3**	**81.5**	10 U	**79.9**	**40.2**	10 UJ	10 UJ	**78.1**
PCB-147	**0.0047**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-148	0.003 U	0.03 UJ	**0.206**	10 UJ	**73.1**	10 UJ	10 U	**107**	10 UJ	10 UJ	**17.8**	10 UJ
PCB-150	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	**17.9**	10 UJ	10 UJ	10 UJ
PCB-151	**0.0744**	**0.086**	**0.248**	10 UJ	10 UJ	**72.7**	10 U	**151**	**43.6**	10 UJ	10 UJ	**46.8**
PCB-152	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-153	**0.3**	**0.405**	**0.639**	43.1 B	**338**	**440**	28.3 B	**626**	**319**	**137**	**154**	**432**
PCB-154	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-155	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	**23.8**	**196**	10 UJ	10 UJ	10 UJ
PCB-156	**0.0365**	**0.0649**	**0.0611**	10 UJ	**43.9**	**63.8**	10 U	**69.6**	**43.7**	**34.4**	**30**	**39.5**

IUPAC	West LL - Zone 1	West LL - Zone 2	West LL - Zone 3	West LL - Zone 3C	West LL -Zone 3B	West LL - Zone 2	Gardens	SR1-2	OR1-4	AP1-2	MI2-2	MI2-2 Rep.
	Sediment (ug/Kg)			Stormwater (pg/L)				Wastewater (pg/L)				
PCB-157	**0.0092**	0.03 UJ	0.03 UJ	10 UJ	**17.5**	**20.8**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-158	**0.039**	**0.0736**	**0.092**	10 UJ	10 UJ	**80.4**	10 U	**51.8**	**18.9**	10 UJ	**20.5**	10 UJ
PCB-159	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-160	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-161	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-162	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-163/164	**0.164**	0.03 UJ	**0.298**	**12.4**	**143**	**185**	10 U	**172**	**69.7**	10 UJ	**58.6**	**105**
PCB-165	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-166	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-167	**0.0153**	**0.0305**	0.03 UJ	10 UJ	10 UJ	**27.5**	10 U	**21.5**	**10.2**	10 UJ	10 UJ	**32**
PCB-168	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-169	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-170	**0.0936**	**0.0883**	**0.273**	10 UJ	**104**	**84.1**	10 U	**80.2**	**34.5**	**24.2**	**61.1**	**33.5**
PCB-171	**0.034**	0.03 UJ	**0.0912**	10 UJ	**22.8**	**26.2**	10 U	**36.4**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-172	**0.0205**	0.03 UJ	**0.0726**	10 UJ	10 UJ	**21.5**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-173	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-174	**0.146**	**0.115**	**0.499**	10 UJ	**144**	**97.2**	10 U	**162**	10 UJ	10 UJ	**39**	10 UJ
PCB-175	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-176	**0.014**	0.03 UJ	**0.0563**	10 UJ	10 UJ	10 UJ	10 U	**27.2**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-177	**0.0745**	**0.0615**	**0.265**	10 UJ	**74.2**	**48.5**	10 U	**81.4**	10 UJ	10 UJ	10 UJ	**64.2**
PCB-178	**0.0299**	0.03 UJ	**0.0752**	10 UJ	10 UJ	**14.5**	10 U	**46**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-179	**0.0567**	**0.0371**	**0.237**	10 UJ	10 UJ	**32.4**	10 U	**94.4**	10 UJ	10 UJ	10 UJ	10 UJ
PCB-180	**0.304**	**0.272**	**1.08**	**22.3**	**350**	**257**	10 U	**372**	**209**	**93.8**	**227**	**265**
PCB-181	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-182/187	**0.166**	**0.127**	**0.624**	**12.8**	**190**	**105**	10 U	**225**	**72.9**	**48.4**	**134**	**189**
PCB-183	**0.0645**	**0.0579**	**0.227**	10 UJ	**75.5**	**52.2**	10 U	**96.9**	**43.2**	**13.7**	**45**	10 UJ
PCB-184	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	**549**	10 UJ	10 UJ	10 UJ
PCB-185	**0.016**	0.03 UJ	**0.0682**	10 UJ	10 UJ	**10.8**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-186	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-188	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-189	**0.0049**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-190	**0.0263**	**0.0317**	**0.0806**	10 UJ	**26.1**	**24.1**	10 U	**19.7**	**11.5**	**16.8**	**16.2**	10 UJ
PCB-191	**0.0042**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-192	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-193	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	**80.4**	10 UJ	10 UJ

IUPAC	West LL - Zone 1	West LL - Zone 2	West LL - Zone 3	West LL - Zone 3C	West LL -Zone 3B	West LL - Zone 2	Gardens	SR1-2	OR1-4	AP1-2	MI2-2	MI2-2 Rep.
	Sediment (ug/Kg)			Stormwater (pg/L)				Wastewater (pg/L)				
PCB-194	**0.036**	**0.0601**	**0.152**	10 UJ	**73.5**	**51.5**	10 U	10 UJ	10 UJ	**21**	**37.9**	10 UJ
PCB-195	**0.0222**	0.03 UJ	**0.0711**	10 UJ	**23.3**	**21.3**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-196	**0.0435**	0.03 UJ	**0.0853**	10 UJ	**27**	10 UJ	10 U	10 UJ	10 UJ	**17.2**	**33.2**	10 UJ
PCB-197	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-198	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	**66.8**	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-199	**0.0918**	**0.0908**	**0.273**	10 UJ	**108**	**70**	10 U	**90.4**	**39.1**	**17.1**	**138**	10 UJ
PCB-200	0.003 U	0.03 UJ	**0.0346**	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-201	**0.0109**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-202	**0.0148**	0.03 UJ	**0.0564**	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	**49.5**	10 UJ
PCB-203	**0.0356**	**0.0427**	**0.152**	10 UJ	**54.3**	**51.9**	10 U	10 UJ	**25.8**	**20.2**	**94.2**	**63.3**
PCB-204	0.003 U	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-205	**0.0047**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ
PCB-206	**0.0343**	**0.032**	0.03 UJ	10 UJ	**95.5**	**51.1**	10 U	**46.4**	**46.5**	10 UJ	**270**	10 UJ
PCB-207	**0.0055**	0.03 UJ	0.03 UJ	10 UJ	10 UJ	10 UJ	10 U	10 UJ	10 UJ	10 UJ	**13.5**	10 UJ
PCB-208	**0.0109**	0.03 UJ	**0.048**	10 UJ	**47.6**	**26.7**	10 U	10 UJ	10 UJ	10 UJ	**103**	10 UJ
PCB-209	**0.0266**	**0.0358**	**0.133**	10 UJ	**84.2**	**44.9**	10 U	10 UJ	10 UJ	10 UJ	**206**	10 UJ

Composite* ***Bold = Visual aid for detected compounds* *U = Not detected at the sample quantitation limit shown*
UJ = Estimated detection limit *J = Result is an estimate* *B = Result less than five times blank contamination.*

Table C-8. Dioxin/Furan 17 co-planar congener results and TEQ calculations
Sediment 2,3,7,8-TCDD TEQs in ng/Kg dw. The lower bound value is the least protective estimate where the non-detected compounds are assigned a value of zero. The upper bound is the most protective TEQ where the non-detected compounds are assigned a concentration equal to the detection limit.

Location	2,3,7,8-TCDF	1,2,3,7,8-PeCDF	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	Lower Bound (ND=0)	Mid Bound (ND=1/2DL)	Upper Bound
Stormwater in pg/L																				
WestLL-Zone 2	**1.69**	**1.79**	**1.34**	**2.04**	**2.2**	**2.57**	1 U	**14.9**	**2.76**	**22.6**	0.5 U	1 U	1 U	1 U	**5.62**	**53.5**	**381**	**2.7**	**3.6**	**4.5**
WestLL-Zone 3B	**1.37**	**1.86**	**1.97**	**1.66**	**2.79**	**1.8**	**2.39**	**14.6**	1 U	**24.6**	0.5 U	**2.38**	1 U	1 U	**3.99**	**56.8**	**331**	**5.25**	**5.6**	**5.96**
WestLL-Zone 3C	**0.56**	1 U	1 U	1 U	1 U	1.49	1 U	**5.83**	1 U	2 U	0.5 U	1.01	1 U	1 U	1 U	30.3	109	**1.61**	**2.33**	**3.05**
Gardens	**0.69**	**2.43**	**3.2**	**2.73**	**2.09**	**4.09**	**3.97**	1 U	1 U	**7.45**	**1.51**	**3.3**	**2.19**	**2.45**	**3.47**	**11.1**	**39**	**8.14**	**8.15**	**8.16**
Storm-drain Sediment in ng/Kg DW																				
Alpine-Zone 1*	**0.39**	**0.95**	0.5 U	**1.39**	**1.72**	**2.31**	**0.5**	**31.9 N**	**2.53**	**88.1**	**1.1**	**3.83**	**3.7**	**8.05**	**6.48**	**188**	**1810**	**9.09**	**9.19**	**9.29**
Alpine Zone 1 Rep*	**0.3**	**0.72**	0.5 U	**1.06**	**1.41**	**2.09**	0.5 U	**21.4 N**	**1.54**	**60.7**	**0.82**	**3.13**	**2.85**	**5.93**	**4.77**	**151**	**1380**	**7.98**	**8.08**	**8.18**
Wright-Zone 2	**0.44**	0.5 U	0.5 U	**0.61**	**0.7**	**1.08**	0.5 U	**7.03**	0.7 U	**10.5**	0.2 U	**0.72**	**0.79**	**2.49**	**1.78**	**44.8**	**241**	**2.1**	**2.31**	**2.52**
Lilac-Zone 3*	**0.68**	**0.79**	**0.89**	**2.11**	**1.78**	**3.32**	**0.56**	**25.8**	**1.79**	**61.8**	**0.3**	**1.87**	**2.58**	**6.46**	**6.02**	**177**	**1290**	**7.26**	**7.26**	**7.26**
Wastewater in pg/L																				
Influent Day*	**0.64**	**3.1**	**2.5**	**1.89**	**1.84**	**2.25**	**2.26**	1 U	1 U	**12.3**	**1.9**	**5.69**	**2.7**	**3.19**	**4.4**	**10.1**	**104**	**10.49**	**10.5**	**10.5**
Influent Day Rep*	**0.64**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**8.42**	**2.17**	1 U	1 U	1 U	1 U	**6.09**	**65.3**	**2.32**	**3.34**	**4.37**
Influent Night*	0.5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**3.86**	0.5 U	1 U	1 U	**1.64**	1 U	**4.16**	**27.9**	**0.22**	**1.47**	**2.72**

Location	2,3,7,8-TCDF	1,2,3,7,8-PeCDF	2,3,4,7,8-PeCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	OCDF	2,3,7,8-TCDD	1,2,3,7,8-PeCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	OCDD	Lower Bound (ND=0)	Mid Bound (ND=1/2DL)	Upper Bound
AP1-2	**0.72**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 U	0.5 U	**1.18**	1 U	**2.52**	1 U	**2.94**	**22.2**	**1.54**	**2.27**	**2.99**
MI2-2	0.5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 U	0.5 U	1 U	1 U	1 U	1 U	1 U	**15.4**	**0.005**	**1.31**	**2.62**
MI2-2D	**0.59**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 U	0.5 U	1 U	1 U	1 U	1 U	1 U	**8.84**	**0.062**	**1.34**	**2.62**
SR1-2	0.5 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**5.4**	0.5 U	**1.65**	1 U	1 U	**1.26**	**6.35**	**53**	**1.86**	**2.61**	**3.36**
OR1-4	**0.89**	**1.54**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**8.28**	0.5 U	1 U	1 U	1 U	1 U	**3.93**	**33.9**	**0.187**	**1.45**	**2.71**

** Composite* *ND = non-detect* *DL = detection limit* *Rep = replicate*

***Bold** = Visual aid for detected compounds* *U = Not detected at the sample quantitation limit shown* *N = Tentatively identified*

Table C-9. Total phosphorus results from stormwater

Location	tP (mg/L)
Gardens	0.044
West LL-Zone 2	0.778
West LL-Zone 3B	0.956
West LL-Zone 3C	0.557
West LL Avg	0.764

Table C-10. Total phosphorus results from wastewater

Sample ID	tP (mg/L)
AP1-2	8.1
MI2-2	7.76
OR1-4	8.23
SR1-2	4.92